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34 B STRANDVEJ, HELLERUP – DANEMARK

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E. S. RUSSELL

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ANDR. FRED. HØST & FILS
COPENHAGUE

AOÛT 1934

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IMPRIMERIE A/S L. IHRICH

The North Sea Cod.

By

Michael Graham,
Fisheries Laboratory, Lowestoft.

I. The Safety of the Stock.

WHEN the legislator asks whether the cod stock of the North Sea is safe, our answer cannot be final. The enterprise of the fishing industry leads to frequent changes of method, and we can only say, "So far, there is only such and such danger", or "So long as coal remains at its present price, no further diminution in fish stock may be expected", and similar temporary answers. So that, although it is now 22 years since Russell began the observations from which we could learn how to answer the questions about stock, and although it has taken several hundreds of pages to explain how we arrive at our opinion, the answer of this year may not apply next year, and the question must be put again. Thus, already there is lying on my table a short series of half a dozen percentages which may render obsolete the reassuring opinions published only this year.[1])

Our aim has therefore been to find a sensitive indicator of the effect of fishing on the stock, which can be examined frequently, say every year. This has been partially successful. As yet there is no way of deciding from one examination whether the movement of the indicator is a mere oscillation, due to its imperfection, or the start of a sustained movement. One year's examination is only a warning or a reassurance. To have even so much so quickly is thought to be valuable, and a short run of years is sufficient to establish any definite trend.

Naturally, it has been necessary to engage in all the usual biological researches — investigations of age, maturity, migrations and the rest —

[1]) The following papers on cod and connected investigations have been published in the English Fishery Investigation Series II: Russell 1922; Graham *et al.* 1924; Johnstone, Scott and Smith 1924; Meek 1924; Gardiner and Graham 1925; Graham, Carruthers and Goodchild 1926; Graham 1929 (2 papers); Graham 1934. The present essay is based on evidence set out in full in these papers.

in order to arrive at the result; but for the present we will put these aside as having been solved, so that the economic problem may be set out alone.

It has been found possible to make an estimate of the age-composition of the cod landed by steam trawlers at Grimsby, in the whole period 1921—1930, and a similar estimate is now made for every year's landings. About one third of all the cod from the North Sea, landed anywhere and by any method, is landed by these trawlers at Grimsby, and their fishing grounds are widespread. The estimate is, therefore, very comprehensive. The estimate is:

Age-group	0	I	II	III	IV	V	VI	VII
Number per mille	2	351	392	130	55	32	28	11

In the first two or three groups the number in the landings is a poor indication of the number in the sea, owing to net selection, but from the III-group onwards we may assume that this cause does not operate, and even the II-group is probably only little affected.

Because the figures refer to a period of 10 years, fluctuations in relative brood strength may be disregarded, and we may use the ratios between successive members of the series as an estimate of average survival. So we obtain:

Age-group	III—IV	IV—V	V—VI	VI—VII
Percentage Survival	42	58	88	39

When we come to individual years, however, we can no longer use the numerical proportions of age-groups to obtain the survival percentage, for the numerical proportions are affected by fluctuations in brood, a good II-brood, for example, automatically depressing the percentage of all other broods. Instead, we use the landing per hundred hour's fishing as a measure of the stock.[1]) So we obtain:

	Number in each age-group per 100 hrs' fishing.							
	0	I	II	III	IV	V	VI	VII
1931	2	251	267	115	60	21	18	9
1932	9	856	534	140	76	35	19	11
1933	5	744	728	162	71	33	20	9

The survival percentage is now obtained by dividing each figure by the figure next above it in the preceding column (that is, we measure the survival of a year-class as a percentage of its abundance in the previous year) and we obtain:

	Percentage survival from age-group:			
	III—IV	IV—V	V—VI	VI—VII
1931—1932	66	58	91	61
1932—1933	51	43	57	47
(1921—1930)	(42)	(58)	(88)	(39)

[1]) This is not the place to digress in justification of this index of the stock. Only in special circumstances, which may be shown not to occur in our case, does this index become misleading.

The first series compares favourably with our average survival percentage for 1921—1930, but the relatively poor survival of fish from V-group in 1932 to VI-group in 1933 *provides first warning* that the relation of catch to stock in 1921—1930 may shortly be superseded.

Here then is the indicator we sought. It is obtainable quickly; within a short time after the end of any year. The results are presented obviously, and it is trusted, they are easy to understand. Data from which it is computed are collected by two observers who measure the length of fish in category samples on Grimsby market and also record the quantities of each category landed, in co-operation with the regular collectors of statistics. The conversion of length-distribution to age-distribution is based on the assumption of average growth-rate, as estimated for 1921—1930, and we also have to use conversion figures for length into weight, given by R u s s e l l. Certainly, several of the processes are approximations, but none of them appear to be biassed in any way, and it is arguable that the estimate is better than has been possible with other species of fish, because of its comprehensiveness. The observers record the landings and measure samples of cod from a fishery that amounts to more than one million hours in a year. They have therefore ample scope to be free from bias, such as may easily arise in the more limited fishing of research vessels, the fishing of a fleet concentrated in time and space, or the smaller number of fish of which the age can be estimated by scales or otoliths. Nevertheless it is to be regretted that the assumption of average growth-rate cannot be checked by scale or otolith observations. This might save some temporary anxiety when a false picture of survival is presented owing to the fish not having grown normally. Unfortunately, however, the North Sea cod, a northern fish near its southern limit, seems to find our winter of insufficient severity for indubitable record on its scales or otoliths. However, irregularity in survival percentages from this cause would be expected only sporadically, so that it would automatically be disregarded in a series of years.

Nevertheless the method is not ideal, nor would we necessarily choose to use it were there an equally good alternative. The chief difficulty is in making sure that the market descriptions in which the quantities are entered correspond consistently with the categories of which the observers measure samples. Nor is it easy to decide how many samples should be measured. Probably future experience will enable these matters to be dealt with sufficiently.

So much for the method of keeping watch on the stock of cod; but what is the basis for interpretation of the indications given by the method? This is the second need in order to answer the legislators' questions. First we need an up-to-date indicator, and also we need a basis for comparison, so that we can say, "When the indicator was as given for 1921—1930 the stock was in no immediate danger, but if the survival percentage falls the question again becomes open." Our basis, then, is the condition of 1921—1930. Why did the observations of the period lead to the opinion that the stock was in no immediate danger?

It must be agreed that criteria are not established sufficiently for us to say categorically whether a stock of fish is yet in danger. Some have held that when fluctuations in landings have increased in amplitude the stock is in danger. Other symptoms which cause anxiety are:— sustained fall in landing per unit of fishing power, increase and then decrease in quantities landed or amount of fishing power engaged, decrease in average size, and contraction of the area of occurrence of the fish. In their early stages, however, none of these processes is harmful, nor should they be interpreted as signs of imminent disaster. They are, at first, merely the signs of healthy exploitation, and only mean that further expansion may not be expected. At best, all that

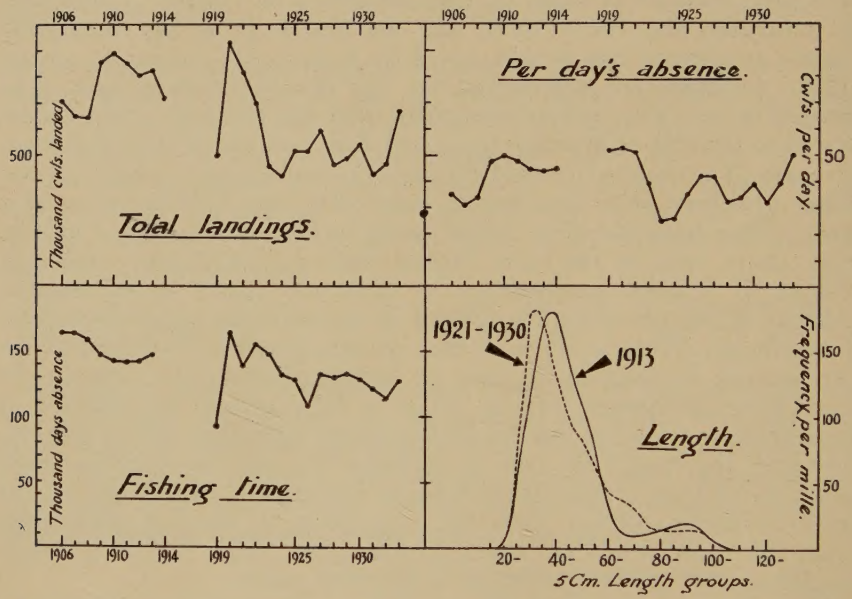

Fig. 1. Indicators of the Effect of Fishing on the Stock of Cod in the North Sea. Drawn from figures in the English published statistics 1924, p. 32, and corresponding tables in later numbers, from Table 45 in Graham 1934, brought up to date, and from Table 1 of Graham 1934.

research can do at present is to exhibit as many relevant symptoms as possible, from which any doctor is entitled to draw his own conclusions as to the future health of the patient.

Statistics to be examined for these critical signs are exhibited in their simplest form in Fig. 1. There we may look for the signs of danger; but we do not find them. There is no alarming fluctuation in the total landing, nor any serious nor progressive fall in landing per unit of fishing time.[1]) Nor is there the rise and fall of fishing power

[1]) It is to be borne in mind that the adoption of more efficient gear may render this statistic a less reliable guide. The Vigneron-Dahl trawl and modifications of it provide an example.

associated with exploitation and depletion, and such changes in length-composition as can be observed are certainly not very significant. As to any contraction in the area of occurrence, we can only speak from common knowledge and say that the cod is just as widespread in the North Sea now as it was in the pre-war period. We may sum up the situation by saying that within the period of our statistics there is no sign of the cod stock entering a decline. We cannot here see even the first stages of the processes which we shall not begin to fear until they are far advanced.

The statistical indications that we have demonstrated are certainly the more weighty of all the considerations that may go to form an opinion as to the security of the stock, but there are some other special circumstances in support. These are:— the observation that the fishing of spawners has no perceptible influence on the numbers of the subsequent brood, the relatively small increase in stock with the war respite, relative protection of the cod by natural causes during part of the year, relative protection of the cod during adolescence, and geographical continuity with more abundant stock. None of these have the same conclusiveness as the statistical indicators we have already considered, but their establishment is clearly relevant, and we may indeed regard some of them as probable causes of the security found. It may quite properly be argued that the resistance put up by the cod stock is due to three of these special considerations, namely, the enormous fecundity which provides for reproduction by the *millionfold,* the respite, even for adults, during part of the year and the protection during adolescence. Certainly, watch should be kept on the degree of this protection, especially since it is known that year by year the fishermen's new methods are designed to reduce it.

These special circumstances may be briefly demonstrated. The first is that the number of spawners does not control the numbers of the subsequent brood. We have an estimate of the numerical strength of brood from the spawning of seventeen years. This estimate is made from the statistics of the youngest marketable codling at Grimsby, by computations that have been fully described. For the abundance of spawners in those years we may use the landing per day's absence (of "Large" cod) for the whole year, or for certain months only. No marked difference has been found using various selections, but it seems well to exclude the months when the cod is heavily fished, otherwise our index would tend to measure destruction as well as abundance. The choice, finally, is of the landing per day's absence, excluding the spawning and herring-trawling seasons, which combines the number available for spawning before the season starts, with the abundance of survivors from the spawning fishery. The two chosen series of statistics are shown in Fig. 2. It is seen that the years when cod were very abundant, 1906, 1908 and 1921, yielded two poor broods and one mediocre. The three worst years for cod did a little better. The two richest broods, 1907 and 1928, came from years of medium abundance of large cod. The two poorest broods came from an

abundant year for cod and from a very poor year. It is shown without any doubt that the success of the brood is but little, if at all, dependent on the number of spawning cod.[1])

The second special consideration, that even the adults have a seasonal respite, can be shown in several ways. It is to be seen in the monthly landing per day's absence year after year. We may illustrate it by taking from a table, showing all the values of this statistic from 1906 to 1930, a few years at random (actually those which happen to

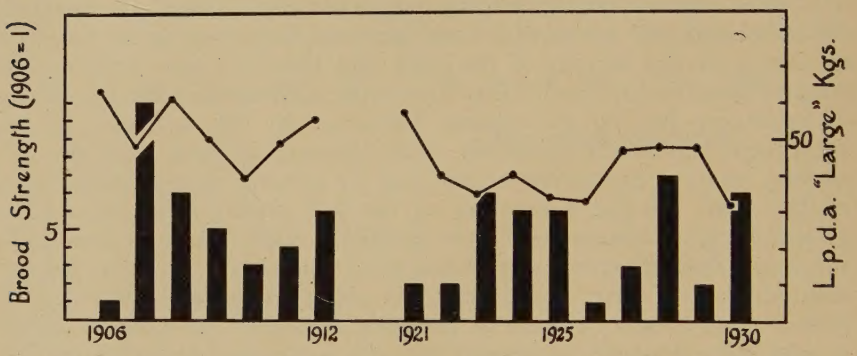

Fig. 2. Abundance of Large Cod and Strength of Brood.
The numerical strength of broods, shown by columns, seems little affected by the abundance of the large cod from whose eggs the brood is hatched. (From data in Graham, 1934, p. 100 and p. 147, column D).

be under certain irregularly spaced dividing lines in the table). Thus we have:—

	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1906	78	99	103	123	77	69	50	57	58	41	37	50
1911	63	90	104	87	45	58	66	69	102	74	43	47
1919	89	238	196	127	100	88	119	203	204	136	91	73
1925	46	69	128	110	68	56	71	85	72	54	41	37

It stands out clearly from the figures that for six months of the year, May, June, July, November, December and January, the trawlers fish for cod less effectively than during the other six. The explanation of this protection from the trawlers was thought to be, pretty certainly, sanctuary afforded by rough grounds, to which the fish resort during early summer and early winter. The point is one that has been discussed at length, and this sanctuary in the roughs seems to be at any rate an important contributory cause. Now, *we know that in recent years there has been an increasing and successful effort to fish the roughs.* So far we have thought that this has not affected the cod stock, but for how long will that be so?

[1]) The correlation coefficient is —0.08, quite negligible.

The third consideration, that cod are relatively protected during adolescence, is an extremely interesting one. It was noticed that curves of length-distribution of cod, such as the two in the last panel of Fig. 1, differ from similar curves for other species, in that there is generally little reduction in frequency near the right-hand end, until the very end is reached. That is to say, roughly as many 90 cm. fish are taken as 80 cm. This was so common a feature that its profound importance was not at first realised. It is, when we come to think of it, somewhat incredible that neither the fishermen, vigorously pursuing these fish on the spawning grounds, nor natural enemies, nor disease, and not even these three lethal agencies combined, do succeed in seriously reducing the 80 cm. fish, judging by their reappearance in equal numbers at 90 cm. a year later. We know, however, that many 80 cm. cod are caught; therefore there must be a further source of 80 cm. cod to maintain the numbers of 90 cm. cod later. In other words, the 80 cm. cod are partly protected.

This argument has been carried through in this somewhat direct and incomplete manner so that the trend in what follows may be more easily traced, and so that it may be seen that the actual age terms we shall use are not necessary to the argument. We should also add, at this stage, that approximate confirmation of our estimate for 1921—1930 is independently given by the 1913 length-distribution, already shown, by some observations of Helland-Hansen, by the observations of 1931—1932, and by a general survey of the statistics of percentage of "Large" to "Medium" cod, such as may be made by consulting Russell's paper.[1])

The full extent of the process is, however, much better seen when the observations are stated in terms of age. We use the estimate of numerical proportion of age-groups in the landings, already given at the beginning of this paper. To the number representing the proportion of the II-group we may as well add the word "plus" to indicate that in the sea there is probably a somewhat larger proportion, but that some of them escape through the nets. We can also calculate and write in the percentag · apparent mortality from one group to the next.

	Age-group					
	II	III	IV	V	VI	VII
Relative numbers	392 plus	130	55	32	28	11
Percentage apparent mortality .	67 plus	58	42	12	61	

Apparently we have a high mortality in the earlier groups followed by a surprisingly small mortality from the V to te VI group, and then a large mortality from the VI to the VII. The last figure is the only one that seems reasonably likely to be a true reflection of mortality. The figures really suggest that the younger groups are not fished as effectively as the VI and VII. In other words the cod are

[1]) It may be seen in such statistics that Russell's chosen year, 1913, was not a year of exceptionally high percentage of "Large" cod.

relatively protected during the years prior to spawning.[1]) (Spawning cod are about equally made up of five and six-year-old fish, with minor proportions of older groups).

To what may this protection be ascribed? The first suggestion is the sanctuary of the roughs that we have considered already. Another, and weight may well be attached to this, is the failure to form such concentrations as will make a fishery. It probably pays a predatory fish to hunt alone, when the prey are many and not hard to find. Shoals, on the other hand, seem advantageous for external fertilisation, and the cod may also gather thickly to the dense herring shoals. In these two cases the cod fish are convenient for the trawl fishery. When the herring are up in the middle and surface waters, however, the cod will probably follow, and then be out of reach of the trawls. If, however, the roughs were the main protection of the cod, such protection has been reduced, and may be still more reduced. The significance of the latest series of survival percentages, mentioned at the beginning of this essay, may now be more fully appreciated, although it was obvious without any further explanation, that reduction in survival percentage called for attention.

II. Prediction.

A distinguished lecturer in chemistry[2]) used to say that he believed in a new chemical substance when they had caught it and put it in a bottle, and although this attitude would have discouraged much valuable research on hormones and vitamins in the early stages, there is here a healthy scepticism that should have its counterpart in all branches of research. In our own, fishery research, we may adopt the criterion that we will believe in a phenomenon when we have reduced it to numerical terms and can estimate its error, although we may often be satisfied with the assurance that the phenomenon is one for which we could, if we would, or sometime hope to be able to, make the necessary estimates. The prediction of the North Sea cod fishery lends itself to this arithmetical description with elegance and simplicity. We can say, two or three years in advance, "Go to the Flamborough Head Ground in February, March and April of 1935 and the expectation of your average landing of large cod per 100 hours' fishing is 64.3 cwt.,[3]) and it is just more likely than not that the average actual landing per 100 hours of all the trawlers will lie between 61 and 68 cwt., and the odds are 10 to 1 that it will lie between 56 and 72 cwt."

The basis of prediction is the relation that has been found between

[1]) The interpretation of the apparent mortality figures is discussed much more fully in my last paper.

[2]) Mr. C. T. Heycock at Cambridge.

[3]) Provided fishing conditions are normal, including the number of trawlers that go. The latter provision raises a pretty point, of predictions that are believed in being automatically falsified, but not thereby being less useful to the fishermen.

the landings of the smallest marketable cod and the landings of large cod three and four years later. The correlation coefficient between appropriate statistics of small and large cod was found to be no less than + 0.96, almost unity. Only seven pairs of observations were available for calculation of this coefficient and it is unlikely that with further material the coefficient will be found to be so high. Nevertheless, there is no doubt that once a brood survives to marketable size its later history does not appreciably alter its relative strength. Furthermore, the numbers of fish in the sea, thus measured, seem to be reflected closely in the landings from the spawning fishery.

The derivation of the numerical estimate of brood strength used in the prediction is a theoretical process, interpreting the commercial statistics of monthly landing with the aid of an estimate of age and growth from other sources. The process can only be described at length, which has been done elsewhere. We will only note, in passing, the claim that the high correlation found is independent confirmation of the estimates of age and growth, which were obtained with great labour, by very unconventional methods. It should also be added that the present predictions are limited to one (very important) fishery, but that other North Sea fisheries are undoubtedly correlated and will probably be included when a longer series of statistics is available.

III. Miscellanea.

It has not taken very long to write out the essentials of the main work of all these years, but it would be rash to accept the conclusions, without the background of knowledge of the fishery and of the biology of the cod, that affords some protection from the danger of disregarding relevant factors. Even so, as knowledge grows from more to more, still more grows the appreciation of our vast ignorance. It is also well to remember that, in the past, small discrepancies and unexplained phenomena have been fully as fertile in production of new discoveries as have the enunciated laws into which they did not fit. The cod workers have perhaps gathered fewer than usual of these wayside flowers, because we have sought our goal, with single purpose. The goal took long enough to reach as it was. Nevertheless, many interesting things have been noticed and it is worth while mentioning some of them here. Who knows what useful trains of thought they may start?

The question of growth-rates is one of the most interesting. In Fig. 3 we have four charts comparing the geographical distribution of two growth-types, rapid and slow, with five factors. Fast growth of very young (pre-marketable) codling is indicated in Chart *a* by shading or solid signs, slower growth by outline signs. A heavily drawn curve separates the areas of rapid and slow growth. This line is transferred to the remaining three charts for comparison with other factors. In Chart *b* we see that it lies in the transition area for

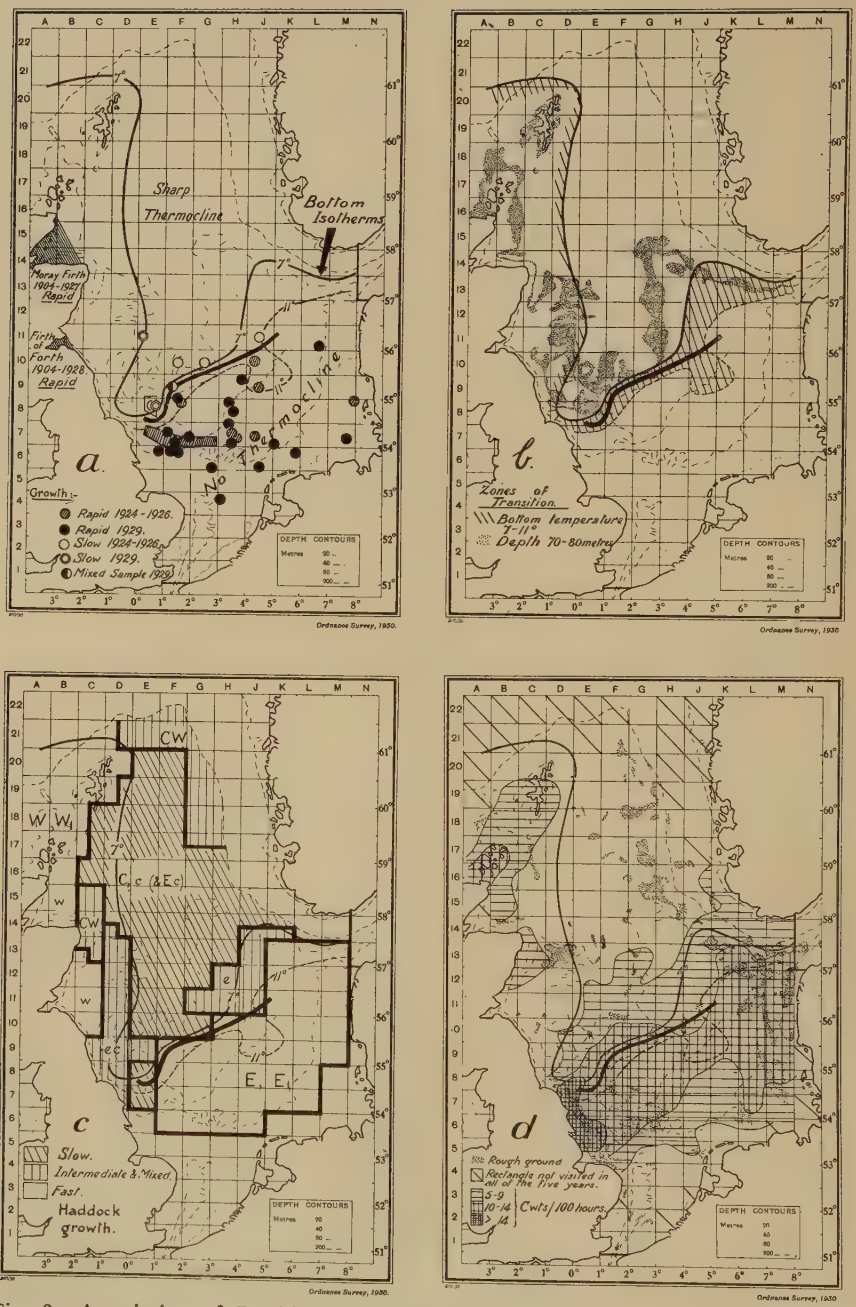

Fig. 3. Association of Rapid and Slow Growth of Codling with Environmental Factors.

From Fig. 15 of Graham 1934.

bottom temperature, separating the area where there is a summer thermocline (Mr. Lumby tells me) from the area where there is no thermocline. The little codling did not grow so fast where there is a summer thermocline. Could this thermocline be the cause of slower growth? It seems reasonable that it should, but, if so, there is something unexplained, because it was found that the difference in growth was largely that the codling in the thermocline area did not grow during the *winter*, when there would be no thermocline. We see in Chart *b* that the growth boundary line also lies roughly in the transition area for depth, and wonder whether there is here any direct effect, without the intervention of temperature. In Chart *c* it is shown from Harold Thompson's work, that haddock growth and cod growth follow the same areas. (It was only observed too late that the shading for haddock growth is the reverse of that used in Chart *a* for codling growth). Finally in Chart *d* we see that the distribution of rough ground is not relevant, nor is slow growth associated with high density of codling, but distinctly to the contrary, which suggests that the codling tend to concentrate in favourable areas. No solution of the problem is now suggested, but one theory would associate fast growth with special quality of the food. It was found that in the area of fast growth the codling stomachs usually contained a larger proportion of crustacean food (compared with piscine food) than in the area of slow growth. This suggests a need for calcium or some accessory food factor. However, the observations included one or two contrary ones, not supporting the association, and the matter is one for further research.

All along, the hydrology of the area has intruded itself into the research. The main result is that investigations by Dr. Carruthers are in hand, with reference to good and bad brood years. Other points have kept cropping up. Mr. Lumby has emphasised the importance of the southern boundary of the cold summer bottom water, the boundary crossing the great cod ground off Flamborough. There have also been indications of a southerly drift of warmer, salter water across the bottom on the spawning grounds, and emphasis has been laid on the occurrence of spawning of fish generally in places and at times when there is normally a drift away from the grounds, apparently towards suitable nurseries. It is thought that this may be as important as is the necessity for suitable density.

Fish migration has as many unanswered questions as bird migration. Such phenomena vie with modern physics in driving the human mind towards refuge in a belief in the supernatural. How does the fish find its way? We think that young cod, less than two years old, work their way from such parts of the area in the Bight of Heligoland as are unsuitable to them, sandy and muddy, to the roughs at each end of the Dogger Bank (as in Chart *d*, Fig. 3). Our knowledge of this movement of young cod is not very certain, but we know very definitely of the gatherings of large cod. We do not yet know why they choose the grounds they do, but we do know that they are

amazingly regular, and we can only safely say that if they were unpunctual or haphazard in their attendance for spawning there would be poor production of fry. It seems that cod may be as local as salmon (we had one good case in our marking experiments) and one is driven to some such explanation as that the cod knows the bottom of the North Sea, along his accustomed routes, fully as well as the oldest of the fishermen, that he has a sence of direction which tells him how many times he has turned round, and that he is rarely, though sometimes, lost. There is at any rate more in the cod's make-up than meets the eye in a casual dissection of the brain.

To refer to a practical detail, we have still failed to find a really good way of marking small fish of a fast growing species, whose tissues are tender. It may be necessary to put up with the present high percentage of loss of marks, but workers who have big aquaria at their stations can do good service if they will make experiments for improvement of the technique, such as are being actively carried out in the U. S. A.

One wonders if there is any special meaning in the millions of eggs? The ling is not so common as the cod, but she has a still greater number. The haddock is more numerous, and has a smaller number. Is there any sense in this, or is it merely that size and numbers of adults are inversely correlated, because of availability of food, and size and number of eggs are directly correlated because a bigger fish can have a bigger ovary?

What makes the rings (winter and summer sclerites) on a cod scale? The argument that faster growth automatically means larger sclerites involves the assumption that the initiation of sclerites is regulated by the clock or the calendar. Is this so? Alternatively, is there an explanation such as has been attempted elsewhere, in the limitation imposed by mass increasing as the cube of a linear dimension and surface only as the square? Can the size of the sclerites be satisfactorily explained by the same factors as cause spacing of the concentric horny layers of the otoliths and the differential structure in the bones, whatever these factors are? Why is scale structure sometimes correlated with growth and sometimes not?

A field for research of much interest still lies in cod liver oil. For generations it has been an effective remedy for several human ailments. Our fathers learned that this was to be attributed to its iodine content. Then we learned that its virtue lay in its vitamins. It was even thought by some people that the natural product would be ousted by irradiated ergesterol. The latest I heard was that there still seems to be some virtue in the natural product that is not to be found in artificial substitutes. All this is extremely suggestive of a fascinating problem, namely, what is the importance of the oil to the fish? We know indeed that there is a vast transfer of oil from the liver to the eggs before they are launched on their hazardous and self-dependent voyage, and we wonder why there are these special properties in the storage substance of livers in animals that live in the sea. Are the

special properties accidentally derived from the mysterious substance sea-water, in which research yields novel valuable ingredients in every decade, or does marine life require special biochemical protection, with which each fish is perforce provided?

In concluding this essay on the long first stage of this research one may attempt to take stock of the progress made. We have brought one more population of fish into satisfactory observation from the economic point of view. In marine fish, at any rate, the number of stocks of which so much can be said is still small. One thinks of the Pacific halibut and three or four stocks in European waters. We notice that in each case different methods of attack have been used on the problem, and we are still at the stage of inventing methods. We have to use whatever means the conditions allow and the conditions are different in every area, and for almost every species. For the North Sea cod the methods have consisted mainly in various computations of the fishing statistics, and measurements of length. It is unlikely that these methods exactly would be best anywhere else but in the North Sea, nor can I use exactly the methods that have been successful for the Norwegian cod stock. No doubt, however, modifications of the North Sea methods will be useful elsewhere and for other species. Also we may be sure that if our reasoning has been sound, similar reasoning will be much more widely applicable, for, although our methods must differ, our problems are essentially the same, all over the world and always.

Der Salz- und Temperaturfehler von Thymolblau.

Von

Kurt Buch und **Charley Gustafsson.**

BEI der kolorimetrischen pH-Bestimmung des Meerwassers ist in letzter Zeit als Farbenindikator meist Chresolrot in Anwendung gekommen, dessen Umschlagsgebiet sich jedoch nicht so weit als wünschenswert nach der alkalischen Seite hin erstreckt. Eine Ergänzung durch einen anderen Indikator hat sich demnach als nötig erwiesen. Früher wurde für alkalisches Wasser vielfach Phenolphthalein gebraucht. Da dieser Indikator wiederum recht unhaltbar ist, ist man zu anderen, vor allem Thymolblau übergegangen, für diesen fehlen uns aber bis jetzt genügend zuverlässige und speziell auf das Meerwasser bezogene Bestimmungen des Salz- und auch des Temperaturfehlers. Vorliegende Arbeit bezweckt die Ausfüllung dieser Lücke.

Salzfehler.

Die bisherigen Untersuchungen des Salzfehlers von Thymolblau erweisen ein mit Chresolrot nahe übereinstimmendes Verhalten. Es wurde demnach als ausreichend erachtet, die Bestimmungen ausschliesslich mit optischen Mitteln unter Bezugnahme auf letztgenannten Indikator durchzuführen, dessen Salzfehler für Meerwasser verschiedenen Salzgehaltes in zuverlässiger Weise von Ramage und Miller elektrometrisch bestimmt ist. Als Kontrolle wurden ausserdem noch parallele Messungen ausgeführt, die sich auf Phenolphthalein bezogen, dessen Salzfehler elektrometrisch von Sörensen und Palitzsch sowie von Buch (2) bestimmt ist. Als Standardpuffer wurde Palitzsch' Borax-Borsäureserie verwendet, die auch bei der Salzfehlerbestimmung von Chresolrot benutzt worden war. Sörensens und Palitzsch' Untersuchungen über Phenolphthalein waren zwar mit Sörensens Borat-Salzsäuregemisch ausgeführt, seine Neutralsalzwirkung ist jedoch mit dem Borax-Borsäuregemisch praktisch identisch. Die Messtemperatur variierte zwischen 19 und 21° C. Die optischen Messungen erfolgten mit Hilfe eines Spektrophotometers nach König-Martens. Für die Messungen mit Chresolrot wurde die

Wellenlänge 570 μμ gebraucht, für die mit Phenolphthalein 551 μμ und mit Thymolblau 591 μμ. Der Indikatorgehalt des Untersuchungswassers betrug für Chresolrot 0.008 g./l., für die beiden übrigen 0.016 g./l. Bei Ausmessung der Lösungen und Überführung in das Messrohr wurden Vorsichtsmassregeln zur Vermeidung der Luftkohlensäure angewandt.

Die Ermittelung des Salzfehlers geschah folgendermassen: Zuerst wurden die Extinktionen der genannten Indikatoren in einer Reihe von Pufferlösungen bestimmt, und die entsprechenden pH-Extinktionskurven entworfen. Sodann wurden Extinktionen von verschiedenen Meerwasserproben mit variierenden Salzgehalten mit denselben Indikatoren und unter denselben Kautelen gemessen und das scheinbare pH graphisch den genannten Kurven entnommen. Die Differenz der pH-Werte, unter Hinzufügung des schon vorher bekannten Salzfehlers von Chresolrot bzw. Phenolphthalein, ergab den gesuchten Salzfehler:

Salzfehler Thym. bl. = Salzfehler Chr.r. + pH (Th.bl.) — pH (Chr.r.)

Wenn die früher bestimmten Salzfehler von Chresolrot und Phenolphthalein richtig waren, so mussten die durch Vergleich mit diesen beiden Indikatoren erhaltenen Werte des Salzfehlers von Thymolblau untereinander übereinstimmen. Diese Übereinstimmung erwies sich auch als vorzüglich für Wasserproben mit höherem Salzgehalt. Unter 10 ‰ traten jedoch Abweichungen auf, deren Ursache in dem Umstande gefunden wurde, dass in den älteren Salzfehlerbestimmungen von Phenolphthalein, sowohl denen von Sörensen und Palitzsch als auch denen von Buch, jeder Wasserprobe mit niedrigem Salzgehalt eine geringe Menge Boratpuffer zugesetzt worden war, um den pH-Wert zu stabilisieren, in der Annahme, dass dieser Zusatz keinen merkbaren Einfluss auf den Salzfehler ausübe. Solch ein Zusatz, der bei den Messungen von Buch den Salzgehalt um ca. 0.2 ‰ erhöhte, und auch mit berechnet wurde, erwies sich nun als unstatthaft, wie aus den eigens zur Klärung dieser Frage angestellten Versuchen hervorgeht (Vgl. Tabelle 2 b und Fig. 1). Wie gross der Einfluss der Qualität des Salzes ist, geht im übrigen schon aus dem Umstande hervor, dass z. B. Chresolrot in einem Meerwasser, welches die gleiche Ionenstärke wie die Borax-Borsäurepuffer besitzt, nämlich ca. 12.5 ‰, dennoch einen Salzfehler (bezogen auf denselben Puffer) von 0.20 pH-Einheiten aufweist. Für Salzgehalte under 10 ‰ können wir demnach unsere Bestimmungen an Thymolblau nur auf die von Ramage und Miller an Chresolrot erhaltenen Resultate beziehen. Leider haben diese Forscher jedoch auch keine direkten Messungen bei diesen Salzgehalten angestellt, sondern ihre experimentelle Salzfehlerkurve unter 10 ‰ auf Grund der Übereinstimmung im Verlauf mit älteren elektrometrischen Messungen von Wells extrapoliert. Diese wiederum waren, weil nicht auf Wasser von 0 ‰ bezogen, nicht direkt vergleichbar. So zeigt es sich schliesslich, dass die Salzfehler aller genannten Indikatoren für Wasser niedrigster Salzgehalte an Zuverlässigkeit zu wünschen übrig lassen. Wahrscheinlich sind Ramage und Millers Werte jedoch einigermassen richtig.

Die Resultate der Extinktionsmessungen an Pufferlösungen sind in der folgenden Tabelle 1 zusammengestellt. Von Chresolrot wurden zwei Präparate gebraucht, No. 1 ist eine Stammlösung von 0.2 g./l., über ein Jahr alt und nach der Vorschrift von Clark bereitet, No. 2 eine in derselben Weise frisch hergestellte Lösung. Erstere wies auffallenderweise eine bedeutend höhere Extinktion auf. Auf die Salzfehlerbestimmungen hatte dieser Umstand natürlich keinen Einfluss, da bei den Messungen an Meerwasser und Puffer stets nur die mit demselben Präparate versetzten aufeinander bezogen wurden.

Tabelle 1.

pH	Thymolblau 0.016 g./l. bei 591 μμ	Chresolrot No. 1 0.008 g./l. bei 570 μμ	Chresolrot No. 2 0.008 g./l. bei 570 μμ	Phenolphthalein 0.016 g./l. bei 551 μμ
8.08	0.1217	0.458	0.239	
8.31	0.1808	0.577	0.307	
8.51	0.252	0.661	0.364	0.0400
8.69	0.327	0.741	0.408	0.0756
8.84	0.403	0.788	0.435	0.1259
8.98	0.476	0.838	0.459	0.211
9.11	0.547	0.873		0.301
9.24	0.607			0.407

Die Extinktionsmessungen an Meerwasserproben und die aus denselben durch graphische Interpolation aus den Werten der Tabelle 1 erhaltenen pH-Werte nebst Salzfehlerwerten für Thymolblau sind in Tabelle 2 zusammengestellt. Die verschiedenen Kolonnen enthalten: 1) Salzgehalt in ‰, 2) Nummer des Chresolrotpräparates, 3) Extinktionswerte von den mit diesem Indikator versehenen Meerwasserproben, 4) pH-Werte graphisch interpoliert zwischen den Werten der Tab. 1, Kol. 3 bzw. 4, 5) korrigierte pH-Werte nach Anwendung der Salzkorrektur von Ramage und Miller, 6) Extinktionswerte von den mit Phenolphthalein versetzten Meerwasserproben, 7) pH-Werte graphisch in angegebener Weise aus Tab. 1, Kol. 5 ermittelt, 8) und 9) korrigierte pH-Werte nach Anwendung der Salzkorrektur von Sörensen und Palitzsch bzw. den von Buch, 10) Extinktionswerte der mit Thymolblau versetzten Wasserproben, 11) entsprechende unkorrigierte pH-Werte (aus Tab. 1, Kol. 1.), 12), 13) und 14) Salzkorrekturen, berechnet gemäss obenerwähnter Gleichung oder, damit gleichbedeutend: die Differenz des korrigierten pH-Wertes (für Chresolrot nach Ramage und Miller, für Phenolphthalein nach Sörensen und Palitzsch bzw. Buch) und des unkorrigierten pH-Wertes für Thymolblau, 15) Mittelwerte sämtlicher Salzkorrekturzahlen. Fig. 1 zeigt den Verlauf der Salzfehlerkurve. Eingezeichnet ist hier ferner eine Kurve, erhalten an Thymolblau und Meerwasser, dem eine kleine Menge (1 : 100; totaler Elektrolytgehalt 0.2 ‰) Borax-Borsäurepuffer (pH = 8.84) zugesetzt worden war.

Die erhaltenen Werte zeigen, wie schon erwähnt, zwischen 34.5 und 11.5 ‰ untereinander befriedigende Übereinstimmung. Die Werte

Tabelle 2 a.

Salzgehalt ‰	Chr.-No.	Chresolrot			Phenolphthalein					Thymolblau				
		Extinkt.	pH unkorr.	pH korr.	Extinkt.	pH unkorr.	pH korr. S & P	pH korr. Buch	Extinkt.	pH unkorr.	Salzkorr. bezogen auf Chresolrot	Salzkorr. bezogen auf Phenolphth. S & P	Salzkorr. bezogen auf Phenolphth. Buch	Mittel sämtl. Zahlen
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
34.5	1	0.745	8.72	8.45	0.0696	8.66	8.45	8.46	0.350	8.74	—0.29	—0.29	—0.28	—0.29
	1	0.741	8.71	8.44	0.0620	8.63	8.42	8.43	0.348	8.73	—0.29	—0.31	—0.30	
24.6	1	0.836	8.97	8.72	0.1569	8.90	8.72	8.71	0.475	8.98	—0.26	—0.26	—0.27	—0.26
	1	0.787	8.82	8.57	0.0877	8.74	8.56	8.55	0.388	8.81	—0.24	—0.25	—0.26	
17.3	1	0.821	8.91	8.68	0.1222	8.83	8.68	8.66	0.445	8.92	—0.24	—0.24	—0.24	—0.24
	1	0.770	8.78	8.55	0.0796	8.71	8.56	8.54	0.386	8.81	—0.26	—0.25	—0.25	
	2	0.440	8.87	8.64	0.1103	8.80	8.65	8.63	0.421	8.87	—0.23	—0.22	—0.24	
11.5	1	0.821	8.93	8.74	0.1307	8.85	8.74	8.71	0.449	8.93	—0.19	—0.19	—0.22	—0.21
	1	0.818	8.92	8.73	0.1363	8.86	8.75	8.72	0.451	8.93	—0.20	—0.18	—0.21	
	2	0.457	8.97	8.78	0.1599	8.90	8.79	8.76	0.487	9.00	—0.22	—0.21	—0.24	
7.26	1	0.817	8.92	8.78	0.1330	8.86	8.79	8.74	0.474	8.98	—0.20			—0.20
	1	0.819	8.92	8.78	0.1261	8.84	8.77	8.72	0.479	8.98	—0.20			
	2	0.427	8.80	8.66	0.0890	8.74	8.67	8.62	0.417	8.86	—0.20			
4.92	2	0.466	9.03	8.92	0.1357	8.86	8.81	8.79	0.496	9.02	—0.10			—0.10
	2	0.459	8.98	8.87	0.1340	8.86	8.81	8.79	0.475	8.98	—0.11			
	2	0.462	9.00	8.89	0.1196	8.83	8.78	8.76	0.475	8.98	—0.09			
	2	0.462	9.00	8.89	0.1209	8.83	8.78	8.76	0.475	8.98	—0.09			
	2	0.457	8.97	8.86	0.1242	8.84	8.79	8.77	0.469	8.97	—0.11			

für 7.26 ‰ und 4.92 ‰, bezogen auf Phenolphthalein, sind dagegen unbrauchbar. Dass hier der Zusatz von Puffer eingewirkt hat, wurde aus den in der Tabelle 2 b angeführten Versuchen und aus der entsprechenden Kurve in Fig. 1 ersichtlich. Die Berechnung der Salzfehler geschah hier in derselben Weise wie in der Tabelle 2 a unter der Veraussetzung, dass die älteren Salzfehlerwerte richtig sind. Wie man sieht, verläuft die Salzfehlerkurve von Thymolblau bedeutend oberhalb derjenigen aus Tab. 2 a, die ohne Pufferzusatz erhalten ist.

Nimmt man an, dass die Salzfehlerwerte von Chresolrot richtig sind, kann man in derselben Weise, wie es für Thymolblau geschah, die

Tabelle 2 b.

17.3	2	0.434	8.83	8.60	0.0985	8.77	8.63	8.60	0.387	8.81	—0.21	—0.18	—0.21	—0.20
7.4	2	0.445	8.89	8.70	0.130	8.85	8.78	8.73	0.429	8.89	—0.15	—0.11	—0.16	—0.14
5.0	2	0.439	8.86	8.75	0.116	8.82	8.77	8.74	0.399	8.83	—0.08	—0.06	—0.09	—0.08

Phenolphthaleinsalzfehler berechnen. Eine solche Neuberechnung wurde angestellt und dabei eine Salzfehlerkurve mit der Salzkorrektur Null bei einem Salzgehalt von 5.8 ‰ gefunden, gegenüber 2 ‰ bei den älteren Versuchen. Die neue Kurve würde für 0 ‰ einen absurd hohen positiven Wert ergeben. Diese Umstände deuten darauf hin, dass Ramage und Millers Wert für 5 ‰ nicht so ganz zuverlässig ist. Es müssten hier erneute elektrometrische Salzfehlerbestimmungen einsetzen.

In Tabelle 3 sind die Salzfehler von Thymolblau für verschiedene Salzgehalte ausgerechnet.

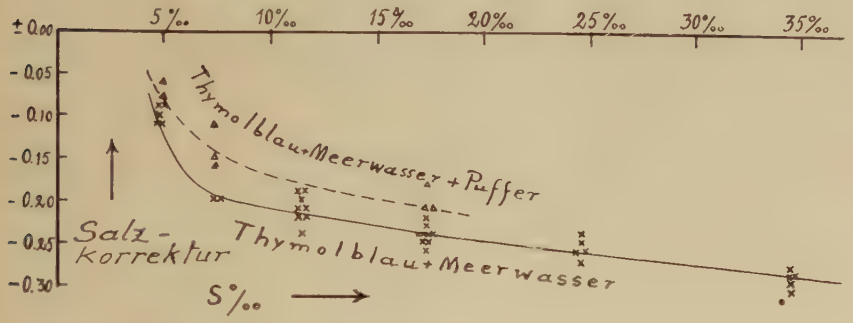

Fig. 1.

Tabelle 3.

‰	5.0	5.2	5.4	5.6	5.8	6.0	6.5	7.0	8.0	9.0
zkorr. ..	—0.12	—0.13	—0.14	—0.15	—0.16	—0.17	—0.18	—0.19	—0.20	—0.20
‰	10	11	12	13	14	15	16	17	18	19
zkorr. ..	—0.21	—0.21	—0.22	—0.22	—0.23	—0.23	—0.24	—0.24	—0.24	—0.24
‰	20	21	22	23	24	25	26	27	28	29
zkorr. ..	—0.25	—0.25	—0.25	—0.26	—0.26	—0.26	—0.27	—0.27	—0.27	—0.28
‰	30	31	32	33	34	35	36	37	38	
zkorr. ..	—0.28	—0.28	—0.28	—0.29	—0.29	—0.29	—0.29	—0.30	—0.30	

Temperaturfehler.

Um den Temperaturfehler von Thymolblau zu ermitteln, wurden drei Borax-Borsäurepufferlösungen mit Indikator versehen und die Extinktionen bei zwei verschiedenen Temperaturen gemessen. Die Variation der Temperatur geschah durch Änderung der Temperatur des Raumes, in dem die Lösungen zubereitet und spektrophotometriert wurden. Da die Farbenänderung des Indikators von zwei Faktoren bedingt ist, nämlich von der pH-Änderung der Flüssigkeit sowie von der Änderung der Indikatorkonstanten, und unsere Aufgabe in der

Bestimmung der letzteren besteht, so müssen wir die pH-Änderung der Puffer mit der Temperatur beachten. Wir entnehmen dieselbe der Arbeit von S. W. Brujewicz und N. P. Karpova. Die Ergebnisse sind in Tabelle 4 zusammengestellt, in welcher für die drei untersuchten Pufferlösungen folgende Daten angegeben sind: 1) Messtemperatur 2) pH des Puffers, berechnet nach der Temperaturkorrektionstabelle von Brujewicz und Karpova 3) Extinktionswert und 4) ΔpK = die Differenz der Indikatorkonstanten bei hoher und niedriger Temperatur. Unter den ΔpK-Werten sind die durch Division der ΔpK-Werte mit der Temperaturdifferenz erhaltenen *Temperaturkoeffizienten* d. h. die pK-Änderungen für je 1° C. angegeben. Die Berechnung von ΔpK geschah gemäss früheren Untersuchungen von Buch (3, 4), über die Temperaturabhängigkeit einiger Indikatorkonstanten, die im Zusammenhang mit Studien über die Bestimmung von pH bei verschiedenen Temperaturen ausgeführt worden sind.

Tabelle 4.

Pufferlösung No. 1 $pH_{18^0} = 9.11$				Pufferlösung No. 2 $pH_{18^0} = 8.69$				Pufferlösung No. 3 $pH_{18^0} = 8.51$			
t	pH	Ext.	ΔpK	t	pH	Ext.	ΔpK	t	pH	Ext.	ΔpK
11°	9.19	0.535		10.5	8.75	0.324		10°	8.57	0.243	
			0.105				0.12				0.17
25.5	9.05	0.513		29.0	8.62	0.320		30	8.44	0.265	
Änderung von pK pro 1°			0.0072				0.0065				0.0085

Das Mittel der für die drei Pufferlösungen erhaltenen Werte der Temperaturkoeffizienten von pK beträgt

$$\alpha = 0.0073$$

und ist etwas grösser als der früher von Buch (4) ermittelte Temperaturkoeffizient von Chresolrot (= 0.0053) und kleiner als der von Phenolrot und Phenolphthalein (0.01). Das pH des Wassers wird demgemäss nach den Angaben in der früheren Arbeit von Buch nach der Formel

$$pH_{tw} = pH_{tb} + 0.0073\ (t_b - t_w)$$

berechnet.

Nachtrag.

Nach Drucklegung der vorliegenden Arbeit erschien eine experimentelle Untersuchung von S. W. Brujewicz und B. A. Skopintzew (Temperature and Saltcorrections in the determination of pH in Sea Water; Bull. State Oceanogr. Inst., No. 14, Moscow) in welcher auch Thymolblau behandelt wird. Für 35 ‰ erhielten sie die Salzkorrektur —0.21, wir dagegen —0.29. Die Verf. schreiben: "Sea Water with Thymol blue gives at a 35 ‰ salinity, values of pH by 0.06 larger than with phenolphthalein." Da indessen

die Salzkorrekturwerte für Phenolphthalein von Sörensen und Palitzsch, Buch, Brujewicz und Skopintzew untereinander vortrefflich übereinstimmen, und die pH-Werte eines Seewassers mit Phenolphthalein und Thymolblau gemessen auch gut übereinstimmen, wenn für den letzten Indikator die Salzkorrektur von Buch und Gustafsson angewandt wird, so ist wahrscheinlich die Salzkorrektur von Thymolblau nach Brujewicz und Skopintzew 0.06 bis 0.08 Einheiten zu klein. Korrigieren die Verf. mit dieser Zahl, so erhalten sie Übereinstimmung, sowohl mit ihrer eigenen Phenolphthaleinmessung wie mit der unsrigen. Die Temperaturkoeffizienten stimmen genügend überein.

Summary.

The present paper deals with the determination of the salt and temperature errors of thymol blue, an indicator suitable for pH-determinations in the highly alkaline range, where cresol red no longer gives accurate results. The salt error was determined by comparing the results of spectrophotometric pH-determinations made with thymol blue (using borax buffers as standards) and with cresol red and phenolphthalein, the salt errors of which are known. If the latter are correct, the salt errors determined by comparison with these two indicators separately should give consistent results. The agreement was satisfactory within the salinity range 10—35 ‰. Below 10 ‰ comparison with phenolphthalein led to unlikely values, which was found to be due to the fact that in determining the salt error of phenolphthalein the water samples had been stabilized with small amounts of borax buffers, in the hope that the addition would not influence the salt error. Tests now made in order to control this (Table 2 b, Fig. 1, broken curve) prove that the presence of the buffer notably changes the salt error. Table 1 contains extinction values for the three indicators in a series of buffer solutions. Two preparations of cresol red, an old and a new one, were used, which had different extinction powers, which circumstance, however, does not influence the final result. Table 2 a gives the results of the spectrophotometric determinations of sea water samples together with the calculated salt error, Fig. 1 (continuous curve), the resulting salt error curve, which closely follows that of cresol red. Table 3 contains the salt errors for salinities from 5 to 38 ‰.

The temperature errors were determined by comparing with the spectrophotometer buffer solutions containing the indicator at two different temperatures, after which the temperature coefficient was calculated in the manner earlier described by Buch (3, 4).

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Montagnes et Vallées Sous-Marines du Golfe de Gascogne.

Par

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DEPUIS quelques années, l'utilisation progressive des sondeurs acoustiques dans la navigation et les recherches océanographiques a permis d'améliorer la connaissance du relief sousmarin.

Dans une communication au 52ème Congrès de l'Association Française pour l'Avancement des Sciences, l'auteur du présent article envisageait la possibilité, au cours des nombreuses oscillations relatives qu'a subi le niveau marin sur notre globe, d'une surrection régionale de l'écorce terrestre, ou d'un abaissement de la mer, laissant entièrement à sec la cuvette du Golfe de Gascogne, dont le fond est à 5000 m. au dessous du zéro actuel.

Depuis cette communication[1]), de nouveaux sondages ont été effectués par l'auteur, en partie sur le chalutier rochellais "La Coubre", de la Maison O. Dahl, en partie sur le chalutier lorientais "Men — Gwen", appartenant à Quéré, Lemoigne, et Cie. Ces sondages, mis en place sur la carte, ont singulièrement renforcé l'hypothèse en question.

J'ai pu reconstituer ainsi, pour une zone comprise géographiquement entre 45° et 50° de latitude Nord, bathymétriquement entre 100 et 2000 m., le tracé schématique de nombreuses dépressions assimilables à des vallées fluviales creusées par plusieurs cycles d'érosion et qui paraissent être le prolongement sous-marin de nos fleuves et rivières du versant atlantique.

Cette exploration n'a pu être poussée plus profondément, parce que c'était l'extrême limite (2000 m.) que l'appareil ultra-sonore Langevin — Florisson, dont je me suis principalement servi, permettait "d'échométrer", mais les vallées en question se prolongent bien au dessous de ce niveau.

Il n'appartient pas à un marin de discuter, après tant de grands savants, d'eustatisme et d'épeirogénisme; toutefois, qu'il s'agisse d'un

[1]) Compte rendu de la 52ème session de l'Association Française pour l'Avancement des Sciences. (La Rochelle, 1918).

abaissement général du niveau marin ou de soulèvements régionaux de l'écorce terrestre[1]), il n'est pas douteux qu'au large de nos rivages le sol actuellement immergé ne l'a pas été toujours.

Au dessus du niveau actuel, les géologues connaissent maintenant assez bien les anciens rivages; mais au dessous de ce niveau, le répérage de ces lignes littorales est autrement difficile. Dans nos parages, la seule connue avec certitude se trouve à 105 m. de profondeur environ. Cet ancien niveau de base est très nettement marqué par une ligne de falaises et d'estuaires sous-marins.

William Beebe, au cours de nombreuses plongées dans sa bathysphère[2]), a aussi repéré ce même niveau de l'autre côté de l'Atlantique; il a en outre reconnu, entre 60 et 75 m., une autre pente abrupte qui existe également au large de nos côtes, quoique moins nettement marquée que le niveau — 105. Sans doute y en a-t-il d'autres que l'on ne connaît pas encore: la grande Pente Atlantique (Atlantic Slope), par exemple, a dû être, à une époque, la limite de l'Océan. Mais quel a pu être le niveau extrême atteint, au dessous du zéro actuel? C'est un problème encore irrésolu, mais qui ne paraît nullement insoluble.

Sur leur parcours à travers la pénéplaine sous-marine dite Plateau Continental, les thalwegs que l'auteur de l'article a explorés ont une inclinaison modérée, sans toutefois avoir atteint leur profil d'équilibre. Ils présentent, semble-t-il, des caractères de "jeunesse" et coupent souvent à angle droit les plissements du massif primaire (vallées de cluse). Leur creux ne dépasse jamais 20 m. par rapport aux lignes de faîte avoisinantes. Il va sans dire que le profil de ces thalwegs change totalement à leur arrivée sur la Pente Atlantique.

Une vallée de synclinal existe entre la côte sud de Bretagne et le Plateau servant de support à Groix et aux îles Glénan. Logée apparemment dans un pli-faille[3]), étroite à sa partie Est, évasée en cuvette à son extrémité Ouest, elle servait de collecteur à toutes les rivières coulant en sens transversal, depuis l'Odet jusqu'au Blavet. L'évacuation de ce collecteur a dû se faire autrefois par une vallée orientée au sud-sud-ouest, qui s'est raccordée à la précédente, peut-être par un jeu de capture, entre Basse Jaune et Basse Doun, à l'est des îles Glénan sur l'isobathe actuelle de 50 m. Cette vallée est une de celles dont nous avons exploré le cours jusqu'au niveau de 2000 m. Son arrivée au Talus Continental se fait en un point L. = 46° 40′N., G. = 4° 30′W. (Gr.), où elle coupe l'isobathe 160 m. en faisant un coude pour reprendre une direction Ouest, plus conforme à l'orientation des plis hercyniens, et se précipiter sur la Pente Atlantique par une tranchée en auge, profonde et inclinée. Nous l'avons nommée vallée de "la Coubre".

La puissance et le débit solide d'un appareil de ce genre devaient être formidables; aussi est-il permis de penser que des sondages

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[1]) P. Girardin — La théorie de l'érosion par les eaux courantes. (Bulletin de l'A. F. A. S. n° 113, juin 1933).

[2]) Bulletin de l'Institut Océanographique de Monaco. (N° 629 du 26 août 1933).

[3]) L. de Launay — Géologie de la France. P. 467.

méthodiques mettraient en évidence un cône ou banc de déjections à leur extrême niveau de base.

Un peu plus à l'Ouest, se trouve une vallée qui servait de collecteur aux cours d'eau prédécesseurs de l'Odet, de la rivière de Pont-l'Abbé, du ruisseau de Lesconil et de celui de Guilvinec dont l'amorce sous-marine, décrite et commentée par L. Collin[1]), figure sur la cartographie officielle française (feuille n 5405). Au delà de l'ancien niveau de base mentionné plus haut (— 105 m.), un lit d'une autre époque existe et suit *grosso modo* le méridien de 4 18′ W. (Gr.) jusqu'au parallèle de 47°20′ Nord où il s'infléchit brusquement vers l'ouest formant un coude en équerre. A cette latitude, ce lit est séparé du précédent par une dorsale large de 9 milles, émanant du Plateau des Glénans, avec un minimum de 101 m. d'eau, alors que les thalwegs ont 112 m. dans la vallée de la Coubre et 118 m. dans la vallée de l'Equerre. En aval du coude, la rive gauche, sculptée par l'érosion, est escarpée, puis le thalweg continue en ligne droite jusqu'à sa chute sur la Pente Atlantique, en un point L. = 47° 15′ N., G. = 5° 48′ W. (Gr.), non sans avoir reçu à droite près du méridien 5° 28′, sous 155 m. d'eau, deux lits anciens dont l'un remonte, je le crois, jusqu'à l'anse de la Torche, tandis que l'autre semble être un prolongement sous-marin de la rivière d'Audierne.

Comme on devait pronostiquer, c'est sur la Pente elle-même que nos itinéraires ont révélé la topographie la plus tourmentée semblable à celle que l'on voit sur les flancs des massifs montagneux continentaux; vallées, cirques, cols, cuvettes lacustres, contreforts, aiguilles etc.

Une des régions les plus curieuses de cette Pente, et dont une exploration expéditive m'a permis d'esquisser les principaux traits, est située dans une partie de la carte très pauvre en sondages, aux accores sud-ouest du haut-fond de la Chapelle qu'on croyait jusqu'ici être le point le plus élevé de la région. Mais nous avons découvert, dans le voisinage, un dos d'âne dont le point culminant n'est qu'à 10 m. au dessous de la surface; c'est un émissaire rocheux du massif primaire qu'il serait téméraire de vouloir *a priori* rattacher à un système de plis connu. Cependant, son orientation fait penser à l'anticlinal du Léon qui viendrait réapparaître sur la pente, après une plongée au sein de la pénéplaine sousmarine.

Les deux vallées encaissées et très inclinées que j'ai découvertes à cet endroit sont de deux types classiques, l'une rectiligne, l'autre en méandres, avec un éperon médian à leur confluent. Je les ai baptisées: vallée J. Charcot et vallée L. Joubin, en témoignage d'admiration et de reconnaissance pour les deux maîtres, qui m'ont donné le goût des recherches océanographiques et inculqué les notions scientifiques indispensables pour la conduite de ces recherches.

Comme on pouvait le prévoir, le fond de ces vallées présente des rapides et des chutes, mais nulle part je n'ai constaté, ni à la profondeur limite de mon exploration, ni à un niveau supérieur, un arrêt brusque,

[1]) L. Collin — Evolution de la région de Pont-l'Abbé — Penmarch. (Bulletin de la Sté d'Océanographie de France, 15 juillet 1930).

à l'instar des valleuses de Normandie. J'ai conclu de cette ininterruption que des sondages poussés plus profondément permettraient de suivre leur trace jusqu'à leur ancien niveau de base le plus extrême et j'ai cherché par anticipation à découvrir sur la carte marine (feuille n° 5381 G. de l'île d'Ouessant au Cap Finisterre) un indice de leur présence, en utilisant quelques cotes isolées qu'on y voit figurer au dessous du niveau — 2000 m.

Ce serait se leurrer que de penser construire sur quelques sondes clairsemées un réseau de courbes conforme à la réalité; cependant, l'examen de la carte précitée nous a permis de faire les remarques suivantes que nous soumettons à ceux qu'elles pourraient intéresser.

Quelle que soit son origine géologique, si le "Gouf" de Cap Breton, vallée la plus importante du Golfe de Gascogne, a été à une époque le théâtre d'enruisselement à l'air libre, on doit pouvoir retrouver quelque part l'amoncellement des matériaux entraînés. Or, la carte, si pauvre soit-elle en sondages, permet d'identifier cet ancien dépôt: c'est un banc découvert lors de la pose du câble télégraphique Bilbao—Angleterre, banc long de 80 milles environ orienté au Nord-Ouest, et dont le point culminant 340 m. est situé par L. = 43°45′ N., G. = 2°32′ W. (Gr.). C'est en amont de ce point que la vallée de Cap Breton semble bifurquer presque à angle droit, une branche se dirigeant perpendiculairement aux plis vers le Nord, côté France; l'autre, vers l'Ouest, côté Espagne, pour aboutir enfin dans une grande cuvette à — 5000 m.

La première branche recevait sur sa droite, par 44°50′ de latitude Nord, un affluent connu des pêcheurs sous le nom de "Fontaine" ou de "Fer à Cheval" et qui pourrait bien être un ancien lit torrentiel de la Garonne. La seconde, draînait les eaux des "Prégonas", vallées en corniche orientées dans le sens des plis pyrénéens.

La cuvette a pu être, à la fin du tertiaire ou à une autre époque, un immense lac d'eau douce, car elle recevait tous les cours d'eau dévalant des pentes de l'immense hémicycle compris entre la pointe Penmarch et le Cap Ortegal.

Une objection à cette hypothèse du lac serait qu'aucun relèvement important du fond ne limitât cette cuvette à l'ouest; mais un examen attentif de la carte fait découvrir ce renflement marqué par deux sondes de 3040 et 3070 m. situées sur le méridien de 10°25′ W. (Gr.). Il n'est d'ailleurs nullement certain qu'il s'agisse d'un sommet isolé, et comme il est nettement séparé du massif espagnol par une fosse de 5000 m., sorte de chenal d'évacuation du lac, nous croirions plus volontiers à son rattachement (par une dorsale dissimulée dans un "blanc" de la carte) au massif primaire armoricain, près du haut-fond de la Chapelle. La Chaussée des Bretons pourrait être l'amorce de cette dorsale. En tout cas un relèvement de 4500 m. existe dans cette direction, ce qui suffit à constituer le flanc ouest de la cuvette.

En outre, un autre renflement de même orientation, mais de moindre importance, coupe suivant un diamètre le fond de cette cuvette; il est marqué par 6 cotes: 4750—4790—4760—4720—4750—4720 m. Une

pareille régularité dans le profil fait penser à un dépôt alluvionnaire, morainique ou autre.

Si le mouvement négatif — 5000 m. a existé, et s'il a été causé par un soulèvement de l'écorce terrestre, la pénéplaine sous-marine qui constitue de nos jours le Plateau Continental a dû se trouver alors à près de 5000 m. d'altitude. C'est dire que la température devait y être toujours basse et que les phénomènes glaciaires oun pu concourir au façonnement tourmenté de la Pente, sans qu'il soit besoin pour celà de recourir à l'hypothèse d'une période glaciaire généralisée[1]). Détail typique, un étroit chenal de 5000 m. est nettement indiqué par les sondes de la carte, entre les deux immenses digues parallèles dont il vient d'être question.

Tout celà demande à être confirmé ou rectifié par une exploration méthodique, mais avec les moyens dont on dispose aujourd'hui, le problème géographique du Golfe de Gascogne pourrait être rapidement dégrossi par une seule coupe de sondages distribués sur le méridien de 8 00′ W. (Gr.), entre la côte d'Espagne et le 48ème parallèle.

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[1]) Stanislas Meunier — Les Glaciers et les Montagnes.

Free Ammonia, Albuminoid Nitrogen, and Organic Nitrogen in the Waters of the Pacific Ocean off the Coasts of Washington and Vancouver Island.

By

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Introduction.

Results of the free ammonia, albuminoid and organic nitrogen determinations for the waters of the Puget Sound area during the summers of 1931 and 1932 were presented in a previous paper (3). It was pointed out that, first, the free ammonia was present in quantities bordering on the lower limit of sensitivity of the Wattenberg method; second, the organic nitrogen content decreased with depth; and, third, the albuminoid nitrogen/organic nitrogen ratios averaged 0.47 with the smallest ratios occurring at the greatest depths. In order to determine if these same relationships persist in the far deeper waters of the ocean, additional data have since been secured for the waters of the Pacific Ocean off the Washington coast.

Methods.

Except for free ammonia, the same analytical methods were employed as in the earlier work. The Witting-Buch (2) method for determining free ammonia was substituted for Wattenberg's (8) as an extensive investigation (10) has shown that the former promises great accuracy and sensitivity and yet involves none of the difficulties encountered in the latter. Witting's procedure as originally recommended was followed, although Treadwell's Nessler reagent was substituted for Raben's. This important modification eliminates the non-sensitive range always found when determining small quantities of ammonia in sea water with the latter reagent.

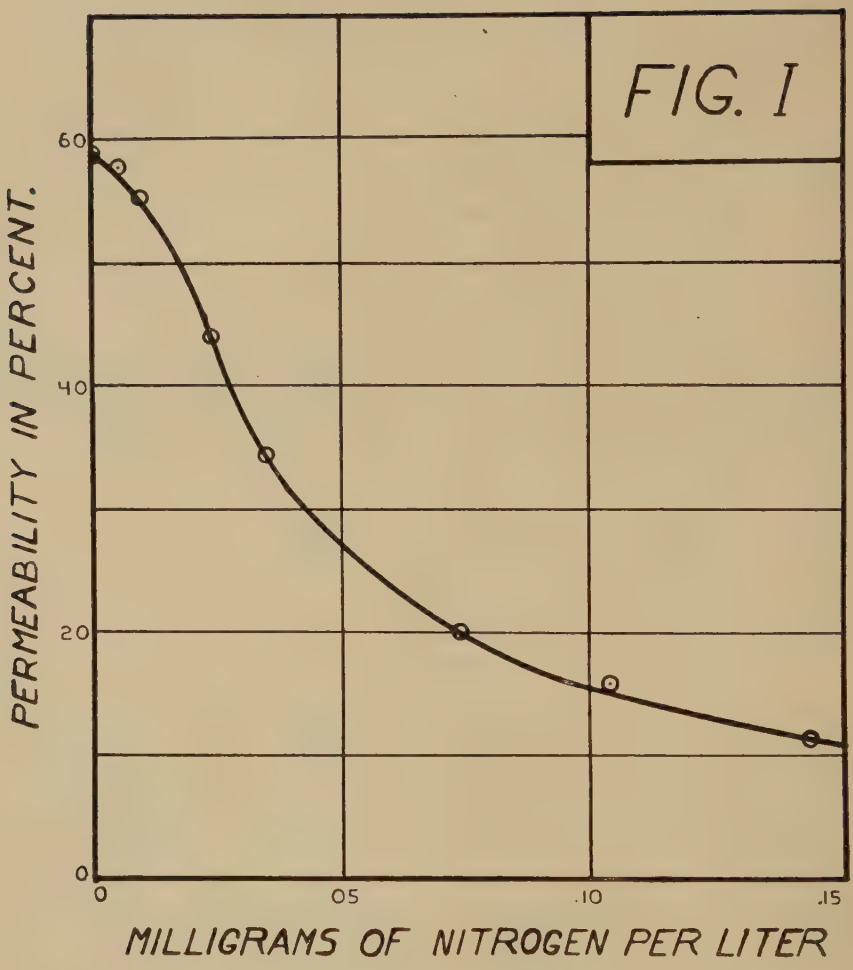

Fig. I.
Permeability of sea water (Cl = 17.0 — 20.0 ‰) containing known quantities of ammonia.

Reagents for the Witting-Buch Ammonia Determinations.

Treadwell's Nessler Reagent: Dissolve 115 grams of mercuric iodide and 80 grams of potassium iodide in enough water to make 500 ml. Add 500 ml. of 6N sodium hydroxide. Two ml. of this reagent are used for every 100 ml. of solution being tested. *Barium Chloride Solution:* Dissolve 200 grams of barium chloride dihydrate per liter. Free of ammonia by partial evaporation and then dilute to original volume with ammonia-free distilled water. *Sodium Hydroxide-Sodium Bicarbonate Solution:* Dissolve 200 grams of sodium hydroxide and 69 grams of sodium bicarbonate per liter. Free of ammonia as in the barium chloride solution.

Procedure.

To 250 ml. of the sample in a 300 ml. bottle are added in succession 10 ml. of barium chloride and 20 ml. of sodium hydroxide-sodium bicarbonate solutions. With chlorinities less than 17 $^0/_{00}$ smaller quantities of reagents are recommended (Cl = less than 11.0$^0/_{00}$, 5 ml. $BaCl_2$; Cl = 11.0 — 13.9 $^0/_{00}$, 6.5 ml. $BaCl_2$; Cl = 14.0 — 16.9 $^0/_{00}$ 8.0 ml. $BaCl_2$, with twice as much $NaOH—NaHCO_3$ in each case). This eliminates the formation of turbid solutions upon nesslerization which is believed to be due to excess of reagents.

The samples reported in this paper were treated with reagents as soon as taken and the analyses completed in the shore laboratory. The time intervening between sampling and nesslerization was kept at a minimum to prevent the formation of ammonia from decaying plankton, though at least three days standing has been found necessary to insure complete precipitation of the magnesium hydroxide. The clear supernatant liquid was siphoned from the precipitate and an aliquot part nesslerized. One half-hour later, the permeability of the sea water was compared with that of untreated distilled water, employing the Zeiss-Pulfrich photometer. The ammonia content of the sample was then obtained from this reading by use of a standard curve. With this method an accuracy of $\pm$ 0.001 mg. of ammonia nitrogen per liter was obtained in the range from 0.000 to 0.050 mg.

Standard Curve.

The permeabilities of nesslerized solutions, prepared from ammonia-free sea water and known quantities of ammonium chloride solution were determined, and from these values a standard curve was constructed. In the preparation of the ammonia-free water the removal of the ammonia by boiling after the precipitation with $BaCl_2$ and $NaOH—NaHCO_3$ gave the better results as turbidities did not then follow nesslerization. In the range 17.0—20.0 $^0/_{00}$, no correction for chlorinity was found necessary as the various standard curves coincided within the limits of experimental error. Figure I is a typical curve for this range.

Location of Stations.

During the summer of 1933 ocean samples[1]) were collected during two cruises of the M. S. "Catalyst", the University of Washington research boat. On one cruise, July 6—8, samples were collected at Stations 31, 34, 39, and 41. The first station was a hundred miles west of Vancouver Island. It was well past the continental shelf, which is approximately twenty-five miles wide in this region. Station 34 was five miles from Vancouver Island on shallow fishing banks. The second inshore station No. 39 was five miles W.S.W. of Tatoosh

[1]) Our most sincere thanks are extended to Prof. T. G. Thompson and Dr. Lyman Phifer of the Oceanographic Laboratories, for the collection of these samples.

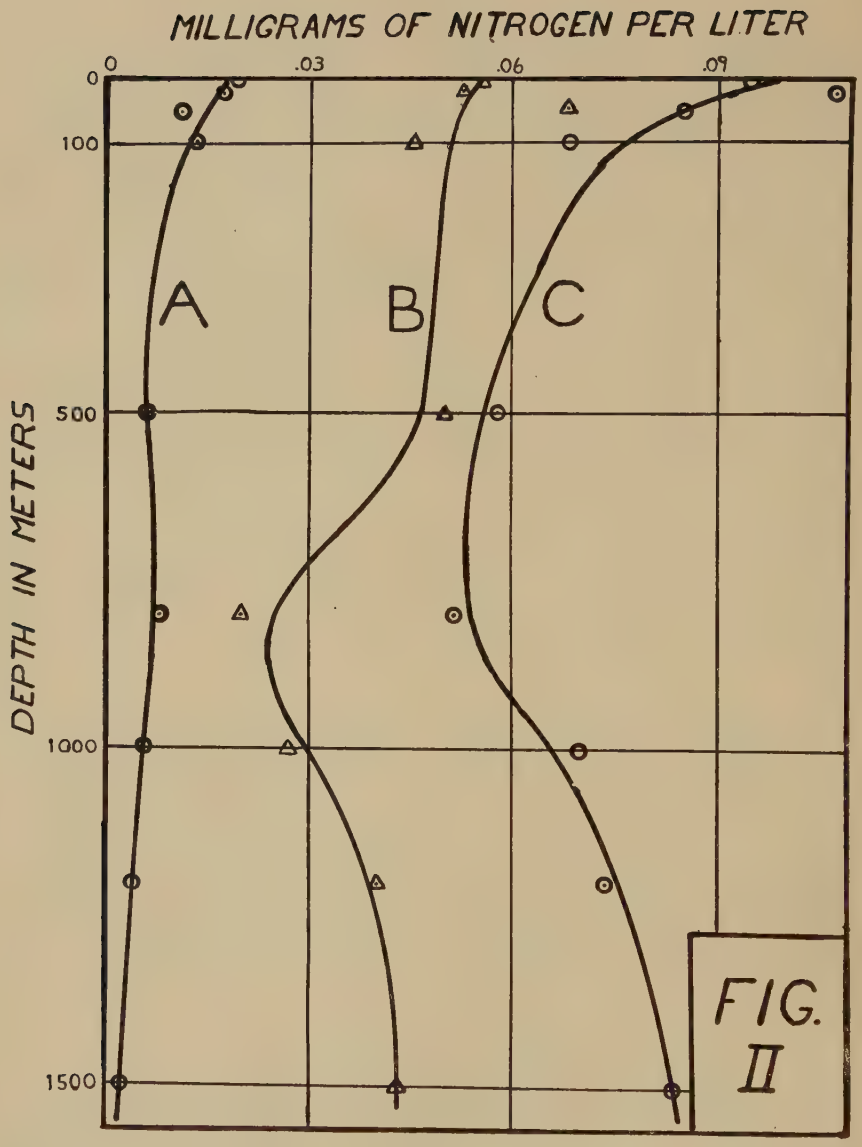

Fig. II.
Average free ammonia (Curve A), albuminoid nitrogen (curve B), and organic nitrogen (curve C) of the Pacific Ocean off the coast of the State of Washington and Vancouver Island.

Island in the submarine valley extending from the Juan de Fuca Strait across the continental shelf. Station No. 41 was located about twenty-five miles inside the Strait. During another cruise of the "Catalyst", July 22—24, samples were collected at Stations 59, 60, 62. The first

Table I.

Station No. 31 49°20′N 127°59′W July 4, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.045	0.05	0.07	0.72	0.01	0.0000
25	.028	.06	.09	.67	.00	.0000
50	.030	.04	.06	.67	.13	.0070
100	.022	.07	.07	1.00	.32	.0000
500	.020	.04	.05	0.80	.69	.0000
1000	.018	.01	.07	.14	.66	.0000
2000	.000	.02	.07	.29	.81	.0000

Station No. 59 49°22′N 129°29′W July 22, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.012	0.09	0.12	0.75	0.21	0.0000
25	.026	.05	.11	.45	.02	.0000
50	.012	.09	.09	1.00	.09	.0050
100	.005	.05	.07	0.71	.20	.0030
300	.004				.48	.0000
500	.005	.04	.06	.67	.69	.0000
700	.001				.72	.0000
800	.023	.02	.06	.33	.72	.0000
900	.001				.93	.0000
1000	.001	.02	.06	.33	.79	.0000
1100	.005				.86	.0000
1200	.013	.02	.05	.40	.88	.0000
1500	.000	.04	.10	.40	.75	.0000
2000	.050				.72	.0000

two were two hundred miles and the third one hundred miles off shore. For greater convenience of discussion the stations have been grouped so that the results of the four deep stations are recorded in Tables I and II, while those of the inshore stations are shown in Tables III and IV. The results given in Tables I and II are presented graphically in Figure II.

Discussion of Results.

Free Ammonia.

Comparatively little ammonia was found in the samples taken at the four deep stations. Of the thirty-nine samples analyzed twenty-three contained 0.005 mg. or less, while only three contained more than 0.030 mg. ammonia nitrogen.

Except for occasional samples most of the ammonia occurred in the upper 100 meters of water, as is clearly indicated by Figure II, (curve A) while below this layer but little ammonia was found. The average for the surface waters of the four deep stations was 0.020 mg. ammonia nitrogen, while at 1500 meters it was only 0.002 mg. This

Table II.

Station No. 60 48°24′30″N 128°01′W July 23, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.013	0.03	0.10	0.30	0.00	0.0000
25	.005	.05	.12	.42	.00	.0000
50	.002	.05	.10	.50	.10	.0080
100	.023	.04	.07	.29	.52	.0000
500	.001	.04	.06	.67	.70	.0000
800	.000	.02	.04	.50	.52	.0000
1000	.004	.05	.06	.83	.72	.0000
1200	.000	.03	.07	.43	.74	.0000
1500	.004	.02	.08	.25	.90	.0000

Station No. 62 47°50′N 125°43′W July 24, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.008	0.05	0.09	0.56	0.00	0.0000
25	.010	.05	.11	.45	.00	.0000
50	.000	.09	.09	1.00	.08	.0050
100	.003	.02	.06	0.33	.42	.0000
500	.000	.08	.06	.?	.82	.0000
800	.000	.02	.06	.33	.81	.0000
1000	.000	.03	.09	.33	1.10	.0000
1200	.005	.07	.10	.70	0.79	.0000
1500	.003	.02	.06	.33	.69	.0000

Table III.

Station No. 34 49°01′15″N 125°46′45″W July 6, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.053	0.07	0.17	0.41	0.07	0.0025
10	.048	.07	.17	.41	.26	.0037
25	.038	.08	.11	.72	.41	.0060

Station No. 39 48°19′N 124°55′W

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_3-N	NO_2-N
	(Milligrams N per liter)					
0	0.031	0.02	0.11	0.18	0.36	0.0038
25	.020	.03	.07	.43	.43	.0033
50	.012	.09	.09	1.0	.48	.0026
100	.004	.10	.08	.?	.48	.0021
200	.015	.06	.07	.85	.52	.0029
300	.077	.00	.03	.00	—	.0006

Table IV.

Station No. 41 48°21′N 124°11′30″W July 8, 1933

Depth (Meters)	NH_3-N	Alb. N	Org. N	Ratio: $\frac{\text{Alb. N}}{\text{Org. N}}$	NO_2-N	NO_3-N
	(Milligrams N per liter)					
0	0.014	0.07	0.09	0.78	0.33	0.0039
25	.012	.08	.09	.89	.31	.0040
50	.008	.06	.10	.60	.40	.0030
100	.000	.05	.07	.71	.50	.0011
175	.001	.07	.07	1.0	.53	.0011

Note: The nitrate and nitrite data in the above tables were obtained by T. G. Thompson and co-workers.

Table V.

Average Albuminoid Nitrogen/Organic Nitrogen Ratios at Various Depths.

Depth	Ratio	Depth	Ratio
0	0.58	800	0.39
25	0.50	1000	0.41
50	0.79	1200	0.51
100	0.58	1500	0.32
500	0.78	2000	0.29

vertical distribution of ammonia agrees with the findings of other investigators (4) (9). Wattenberg (9) attributed the larger quantities of ammonia in the surface waters to the decomposition of dead plankton in the upper, plankton-rich layer while more rapid nitrification prevents the accumulation of ammonia at lower depths.

Samples collected in the Strait of Juan de Fuca (Table IV) likewise showed but little ammonia. It will be noted that these values are not essentially different from those of the deep stations where this water has but recently had its origin (7). Both the shallow inshore ocean stations (Table III) contained considerably larger quantities of ammonia. In the submarine valley the ammonia had a minimum value at 100 meters with much larger quantities at surface and bottom. From an examination of the ammonia data reported it will be observed that the samples with exceptionally high ammonia content were, for the most part, from the waters near the bottom. The waters impregnating the bottom muds have been shown (1) (5) to be especially rich in free ammonia which, in turn, diffuses and enriches the supernatant water. This action might easily account for the greater concentration of ammonia in all three samples at Station 34, though the decrease in ammonia content with depth would result from the usual effects of ammonia formation in the surface waters and vigorous nitrification in the lower depths.

Albuminoid and Organic Nitrogen.

Due to the greatly diminished biological activity in the open ocean the albuminoid and organic nitrogen were present in even smaller quantities than in the inland waters of this region. The average content of albuminoid nitrogen for the four deep stations was 0.04 mg. per liter, and of organic nitrogen 0.08 mg. compared with an average of 0.10 and 0.21 mg. respectively for the inland waters.

Figure II (Curves B and C) gives the vertical distributions found for albuminoid and organic nitrogen. The albuminoid nitrogen was practically constant down to 500 meters, showed a minimum at 800 meters and then increased with depth to an amount slightly less than the surface value. The organic nitrogen decreased rapidly with depth to 100 meters, also had a minimum value at 800 meters, then increased again until at the bottom the surface value was almost equalled.

The lesser quantities of albuminoid and organic nitrogen below the photosynthetic zone and above eight hundred meters may be attributed to the decreasing quantity of plankton. The minimum values found at eight hundred to one thousand meters may be unquestionably correlated with similar minimum values for oxygen reported by Thompson, Thomas and Barnes (7). From a study of various data, particularly temperature, oxygen, chlorinity and carbon dioxide, for the waters of the Bering Sea, Gulf of Alaska and off the coast of Washington, Thompson and his co-workers believe that it is possible this layer of water has come as a subsurface current from the stagnant bottom waters of the Gulf of Alaska. Whatever the origin of this layer may have been, there must be a close relationship between the amount of oxygen and the amount of decomposition that has taken place since somewhen and somewhere the dissolved oxygen present in the water has been utilized in the decomposition of organic material.

The average albuminoid/organic nitrogen ratios for the various depths have been calculated and listed in Table V. As in the deepest waters of the Puget Sound region, the lower depths have the lowest ratios. The average ratio of all the samples above eight hundred meters is 0.57 while those samples at eight hundred meters or below yield an average ratio of 0.40. The abrupt change in this ratio beginning at eight hundred meters indicates that the nitrogeneous material below this depth is of a more stable character. The long absence from a region of biological activity has given an opportunity for the decomposition of the less stable material.

The only reports of the albuminoid nitrogen content of deep waters, as far at the authors are aware, are those of Natterer on the Mediterranean Sea and Raben on the North and adjacent seas as reported by Brandt (8). The average for all samples analyzed by Natterer was 0.103 mg. per liter, the lowest average for any one trip being 0.041 mg. and the highest 0.139 mg. per liter. Raben obtained an average of 0.126 mg. per liter in the North Sea and practically the same quantity in the waters west of the Thomsen Ridge near the Orkney Islands. To these values of Raben and Natterer,

however, should be added a part of the free ammonia reported by them (0.040 and 0.047 mg. per liter respectively) since it is now known that when free ammonia is determined by distillation a portion of the albuminoid nitrogen is liberated as ammonia on boiling. These values are, therefore, approximately three times as large as those reported in this paper. The scarcity of plankton in the Pacific Ocean would naturally result in low values inasmuch as albuminoid nitrogen is closely related to the plankton content.

Summary.

1. The quantity and distribution of ammonia in the Pacific Ocean off the Washington coast corresponds to that found in other oceans.

2. The amount of albuminoid and organic nitrogen is less than that found in the inland waters of this region.

3. Other investigators have reported much larger values for albuminoid nitrogen in the Mediterranean and North Seas.

4. The vertical distributions of albuminoid and organic nitrogen show minima at eight hundred to one thousand meters with greater values at surface and bottom.

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Absorption of Daylight in the North Pacific Ocean.

By

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Introduction.

ALTHOUGH many experimenters have carried out determinations on the absorption of solar radiation in the sea, there is but little data available on the spectral distribution. Spectrophotometric measurements on a four meter column of pure sea water have been made by Hulburt (1). W. R. G. Atkins and H. H. Poole (2), and W. R. G. Atkins (3) have taken some measurements at the International Hydrographic Station E-1. Results obtained in the San Juan Archipelago and in Southern Alaska have been reported by one of us (4). Such measurements are very difficult because of variations in natural conditions such as intensity, quality and distribution of sunlight, surface conditions, change in foreign matter content, etc., etc.

If a beam of homogeneous radiation is incident normally on a plane water surface the intensity, I, at a distance x meters below the surface, will be given by

$$I = I_o e^{-\gamma x} \tag{1}$$

where I_0 is the intensity at the surface and γ is defined by the equation. For any other angle of incidence the relation is

$$I = I_o e^{-\gamma x \sec r} \tag{2}$$

where r is the angle of refraction of the beam in the water. In each of these equations γ represents the total absorption coefficient, a quantity dependent upon the frequency of the light, absorption and scattering by the water, absorption and scattering by foreign matter, and upon any light scattered back into the beam. Hulburt (1) has shown that the light scattered back into the beam due to Raman scattering is small and to a fair approximation may be neglected in comparison to the light absorbed by the water. Scattering, however, may not be negligible when foreign matter is present in the water either in suspension or in solution.

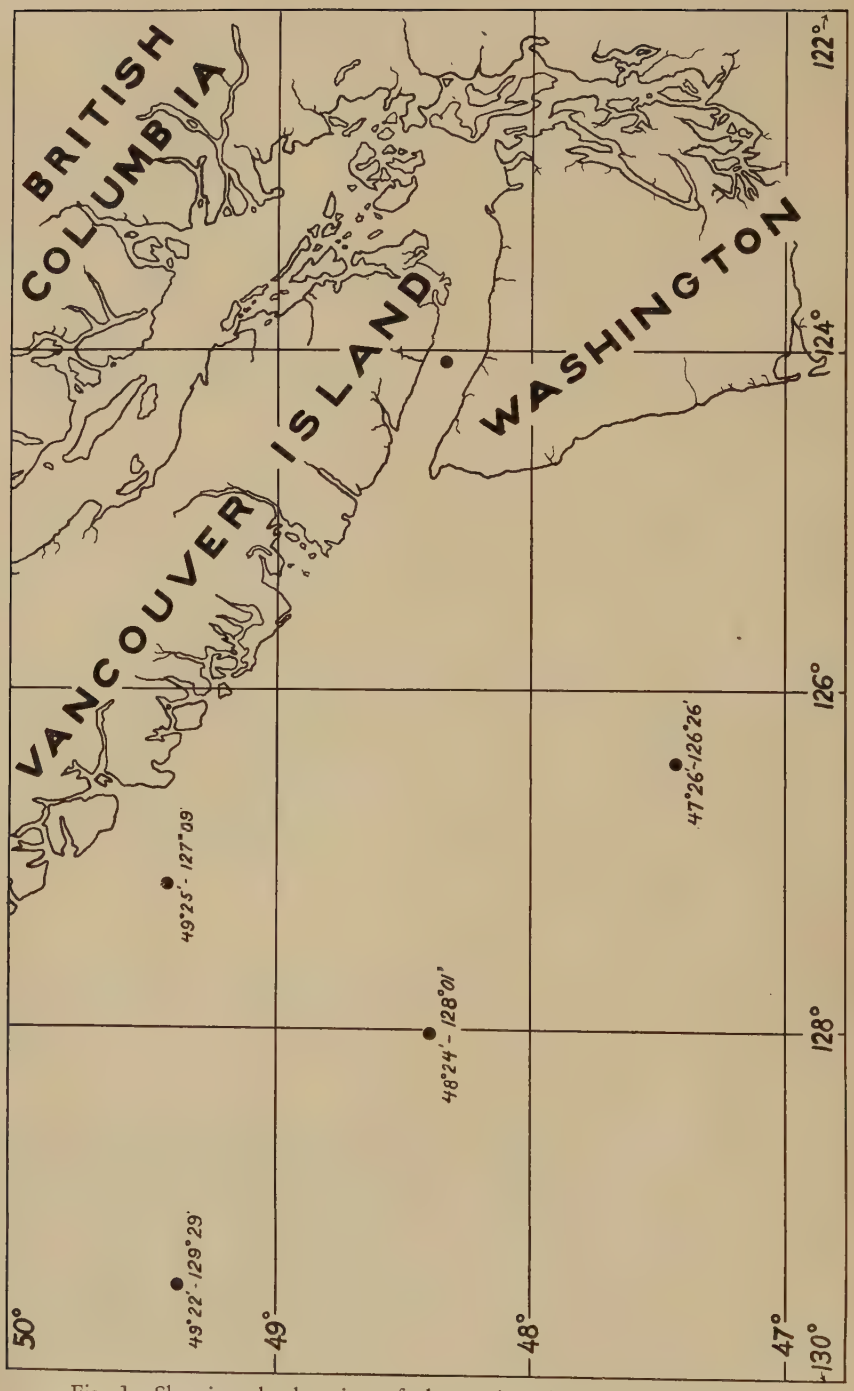

Fig. 1. Showing the location of the stations in the Pacific Ocean with one station in the Strait of Juan de Fuca.

Because of the uncertaintity in the resultant angle of the refracted beam, Atkins and Poole (2) have introduced a quantity which they call the "vertical absorption coefficient". This quantity, by use of which consistent results are obtained, is defined by γ in Equation (1) and refers to the removal of radiation from the beam when x is measured vertically downward although the angle of incidence may not be zero. As the numerical value of γ is, in part, determined by scattering due to the water and to suspended matter, it is not entirely an absorption coefficient. The results of the present work are given in terms of γ, which is called the total vertical absorption coefficient. The term is not entirely descriptive of the process, but at least indicates the meaning.

The purpose of the observations was twofold. It was desired to extend the stations beyond the inshore waters of the North-West to the open ocean, and also to obtain a better spectral distribution of absorption coefficients.

The stations, as shown in Fig. 1, will be referred to by their geographical location of latitude and longitude, with the exception of the one in the Strait. For example, that farthest westward will be called 49°22′—129°29′. The one nearest Vancouver Island will be denoted by 49°25′—127°09′.

The Photometer and Submarine Measurements.

The submarine photometer, formerly described by one of us (4), has been modified to permit the use of seven carefully selected Wrattan filters on the aluminium disk. This permits nearly simultaneous measurements on seven different bands of the visible spectrum. Each filter, with the exception of the yellow, was chosen to give as narrow a transmission as possible. Its transmission band was rather wide, extending somewhat into the red and with a very slight transmission in the ultra-violet at 3200 A. A wave-length has been assigned to the transmission band of each filter. This assignment is somewhat arbitrary because of the nature of the absorption of the water. Former experiments, including the visual observation of Beebe (5), show that the absorption is least in the central portion of the spectrum, so the "effective wave-length" of any filter will shift toward the center of the spectrum with increasing depth, unless, by chance, the effective wave-length of a particular filter happens to be that of least absorption of the water. Obviously the shifting of the transmission band is quite marked in the extreme red and extreme violet. However, all the transmission bands, except the yellow, were fairly narrow, and the wave-length assigned to each band is to be considered as designating a small region of the spectrum rather than the exact effective wave-length of the band.

The aluminium disk, which carried the filters, was actuated by means of an electromagnet which permitted quite rapid shifting of the filters. It has been possible to take a series of 180 measurements in considerably less than 60 minutes. Under conditions where it is

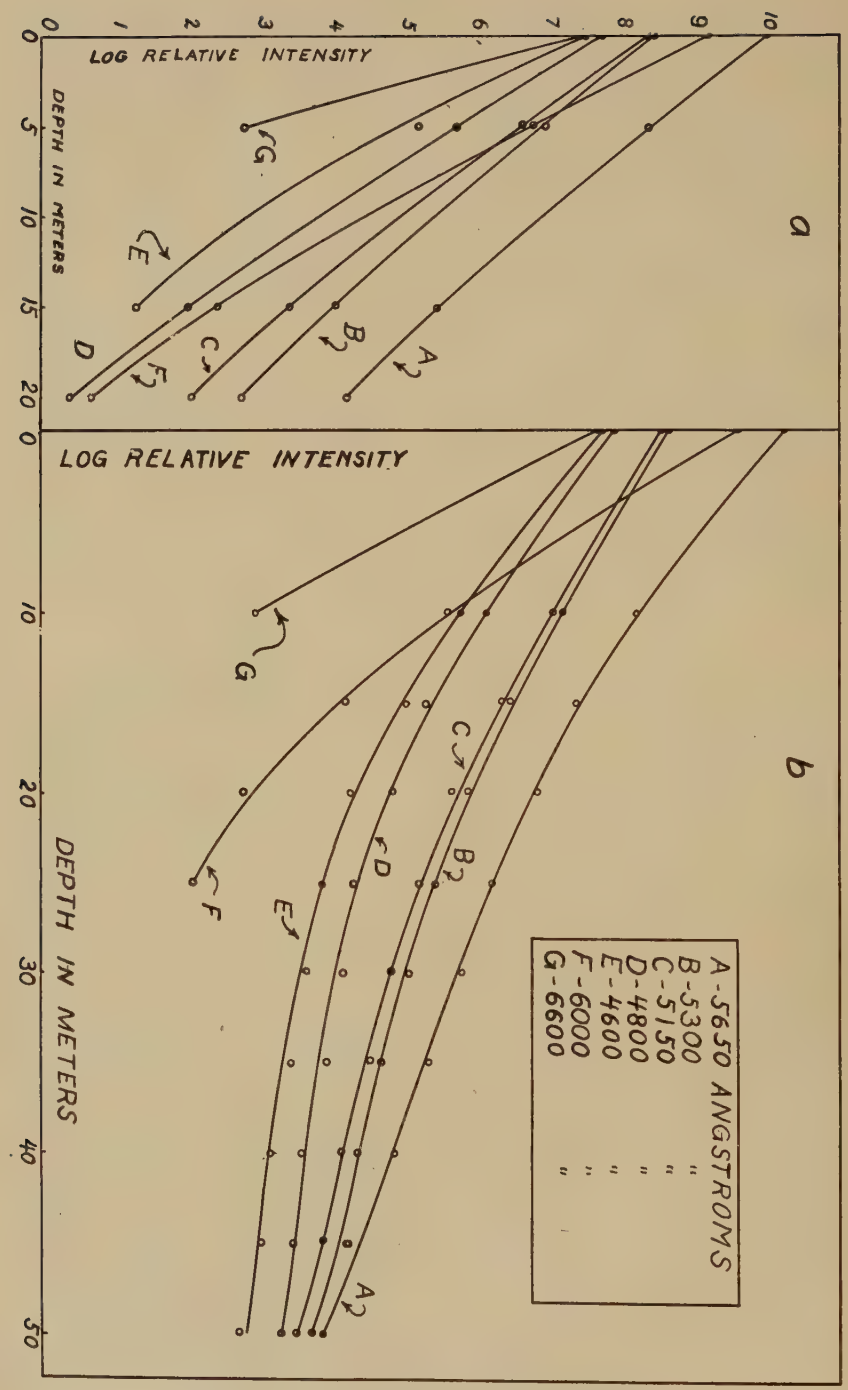

Fig. 2. Transmission curves for Station 49°25′—127°09′, and the station in the Strait of Juan de Fuca.

desirable to measure the relative intensities at 5 or 10 meter intervals, the time occupied in a series of observations is materially shortened. This is of considerable importance in that it affords almost simultaneous readings on various colors at each depth and a very small time interval between observations at different depths. Thus the illumination due to each color may be obtained under comparable conditions which might not otherwise be true, on account of the possible changes in the composition of the surface light and changes in the amount of foreign material in the water.

The intensity at the different depths was compared to the intensity just below the surface. The ship was always kept opposite the sun, so the effect of light disturbances by the boat might be made a minimum. Conditions for observations at the three most westerly stations were exceptionally good. The sky was uniformly overcast and the deck photometer showed that the light was quite constant during the observing period. The sea was calm and the boat was rolling less than 2 degrees. While making the measurements at Station 49°25′—127°09′, the sun was shining brightly with but little variation showing on the deck photometer and the boat was rolling moderately. In the Strait of Juan de Fuca the water was quite choppy with considerable roll to the ship. The sky was clear at the beginning with a slight haze coming on before finishing. The results obtained at this station are not as accurate as those at the four other stations.

Results.

The total vertical absorption coefficients per meter for all of the stations are given in Table I. It will be noticed that they have been computed for 10-meter thicknesses of water except in the case of the station in the Strait of Juan de Fuca. The values were obtained from Equation (1), using γ as the total vertical absorption coefficient.

Figure 2a is the transmission curve for each spectral band at the station in the Strait of Juan de Fuca about 2 miles south of the Jordon River, and Figure 2b shows the spectral transmission at Station 49°25′—127°09′, 28 miles west of Flores Island, about the middle part of the coast line of Vancouver Island.

The transmission curves for the different spectral bands are shown in Figure 3 for Station 48°24′—128°01′, and for Station 47°26′—126°26′. These waters exhibited a very clear blue color, quite in contrast to the water at 49°25′—127°09′ which was characterized by a definite greenish tinge. As the shore of the continent is approached, this greenish tinge becomes more pronounced until, on reaching the inshore waters, it completely masks the blue.

The values of the absorption coefficients of all the wave-lengths have been plotted in Figure 4 and Figure 5 for some of the stations. Figure 4 shows the results for Station 49°22′—129°20′. The upper set of curves in Figure 5 are for Station 47°26′—126°26′, while the lower set of curves are for Station 48°24′—128°01′.

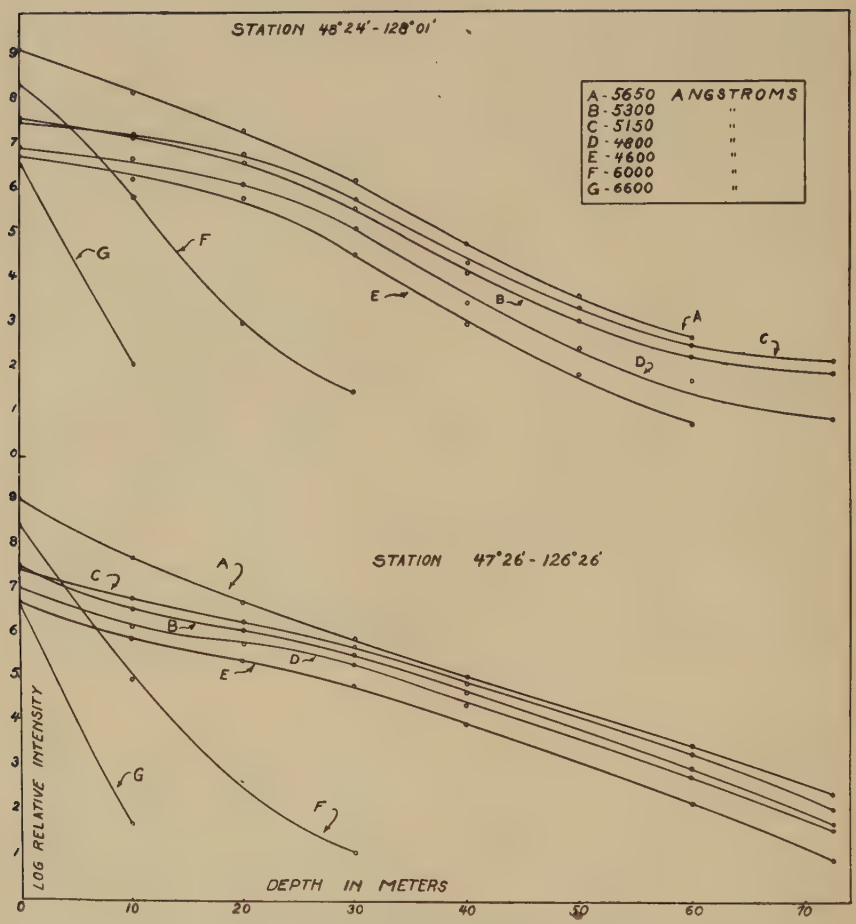

Fig. 3. Transmission curves for Stations 48°24′—128°01′ and 47°26′—126°26′.

It will be noticed that there exists a deviation from exponentiality. For example, the lower set of curves in Figure 5 show a relatively low absorption in the upper layers of the water, increasing to a maximum between 40 and 50 meters, and again decreasing with greater depth. This is true of the short waves, the longer waves being of such low intensity at these depths that measurements of them could not be made.

Samples of the water and vertical net hauls for each depth were taken at each station. At the three stations to the westward, in very clear water, the richest plankton hauls were made between depths of 30 and 50 meters. The absorption coefficients for the shorter waves were greatest at these depths (Fig. 6). While the plankton analysis of this water is not completed, this may have some bearing on the effect

Table I.

Spectral Absorption Coefficients.

Station	Depth in Meters	Total Vertical Absorption Coefficient Per Meter						
		$\lambda = 4600$	4800	5150	5300	5650	6000	6600
Strait of Juan de Fuca	0—5	.434	.388	.320	.294	.344	.462	
	5—15	.412	.374	.328	.292	.290	.452	
	15—20	—	.332	.274	.266	.248	.354	
49° 25′ 127° 09′	0—10	.202	.174	.149	.144	.206	.385	.574
	10—15	.138	.170	.136	.170	.166	.304	
	15—20	.137[1])	.096	.144	.090	.108	.284	
	20—25	.060	.064[1])	.088	.092	.132		
	25—30	.059[1])	.060[1])	.073[1])	.080	.074		
	30—35	.058	.048	.072[1])	.071	.096		
	35—40	.058	.072	.071[1])	.068	.096		
	40—45	.024	.026	.072	.040	.140		
	45—50	.040	.036	.080	.086	.084		
49° 22′ 129° 29′	5—10	.104	.054	.046	.062	.116	.306	.570
	10—20	.091	.086	.093	.105	.110	.286	
	20—30	.079	.065	.070	.076	.091		
	30—40	.059	.084	.090	.083	.092		
	40—50	.071	.062	.043	.072	.066		
	50—60	.047	.053	.055	.060	.096		
	60—70.5	—	.063	.070	.089	.089		
48° 24′ 128° 01′	0—10	.054	.018	.033	.037	.100	.249	.451
	10—20	.041	.064	.035	.060	.083	.291	
	20—30	.130	.099	.105	.106	.109	.156	
	30—40	.162	.170	.146	.146	.149		
	40—50	.104	.101	.097	.106	.118		
	50—60	.118	.069	.085	.083	.095		
	60—72.5	—	.032	.030	.027	—		
47° 26′ 126° 26′	0—10	.081	.088	.063	.094	.148	.338	.488
	10—20	.047	.041	.056	.049	.103	.226	
	20—30	.058	.039	.055	.055	.076	.167	
	30—40	.087	.099	.065	.089	.097		
	40—60	.090	.081	.079	.086	.081		
	60—72.5	.105	.081	.082	.095	.103		

[1]) Weighted mean.

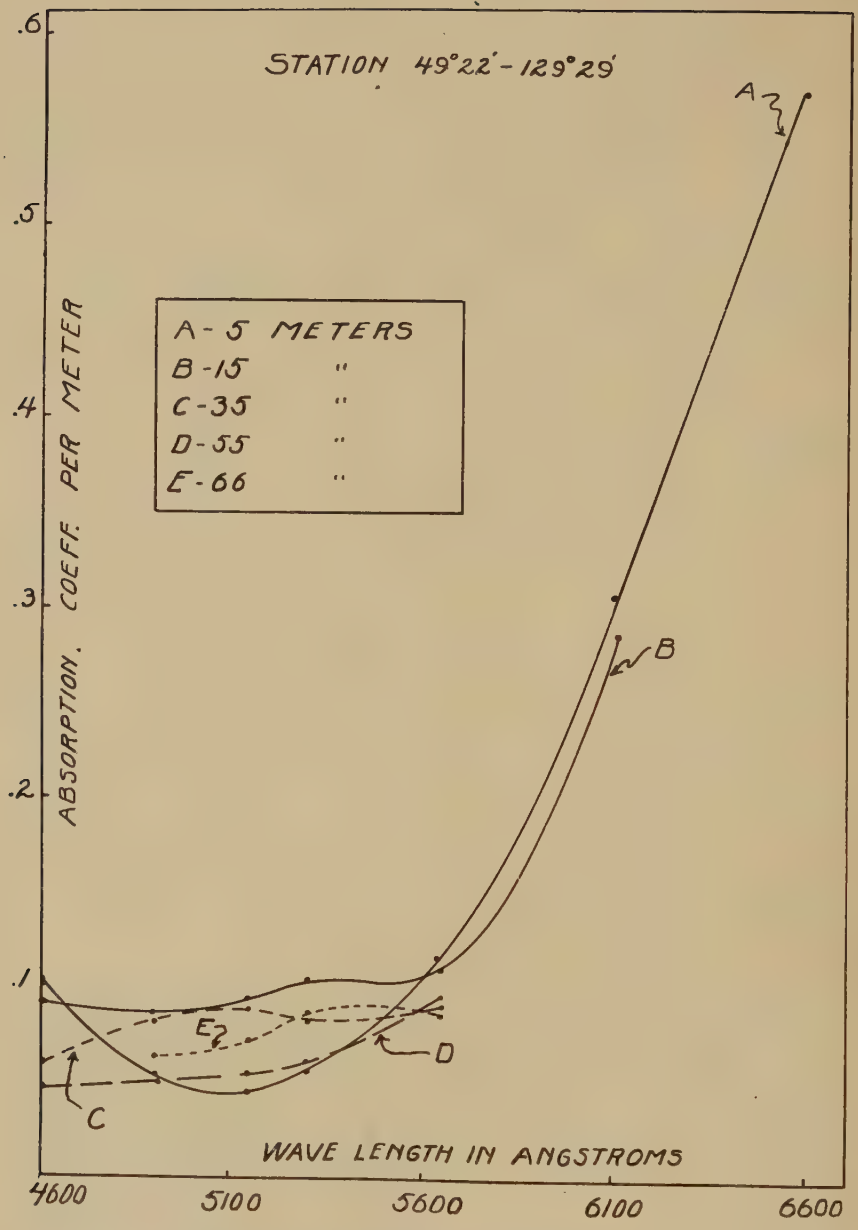

Fig. 4. Absorption coefficients per meter for different wave-lengths and depths at Station 49°22′—129°29′.

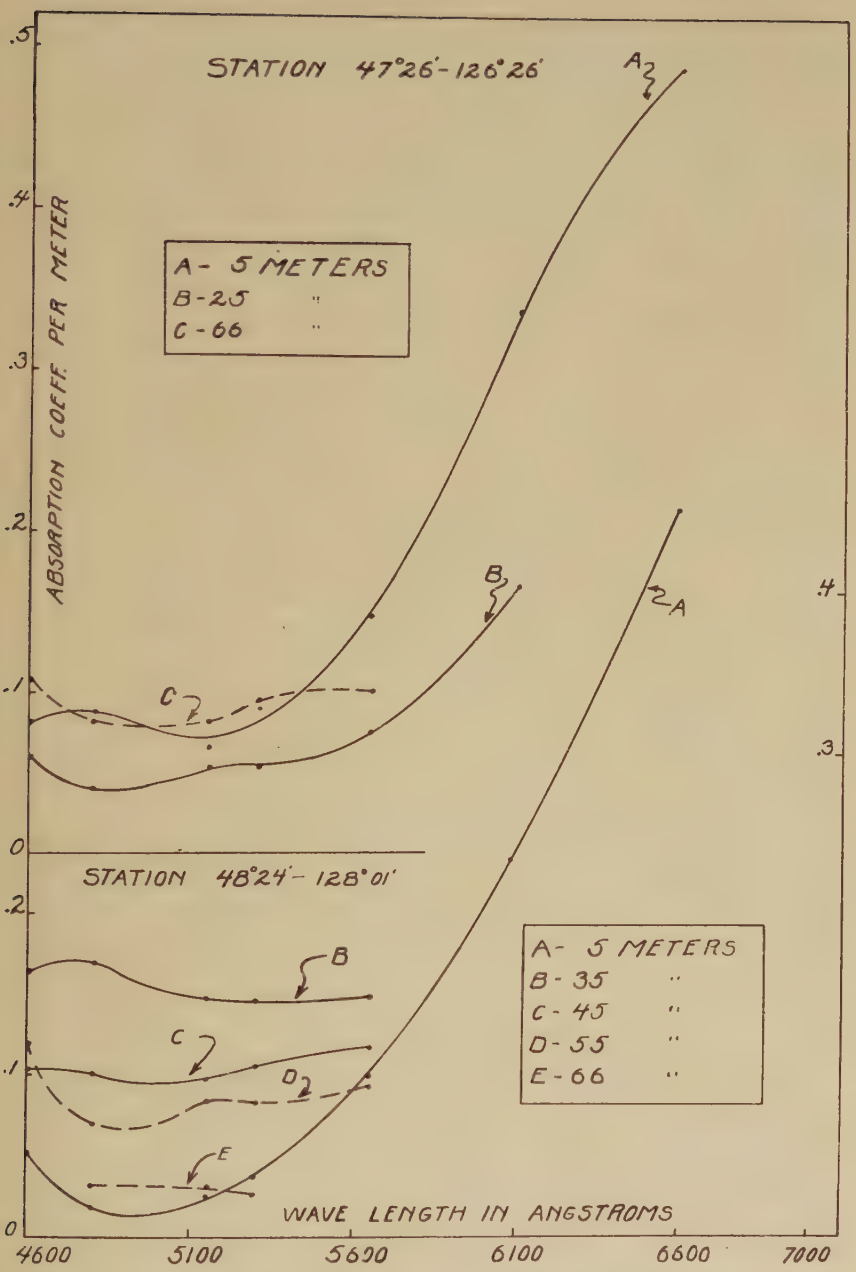

Fig. 5. Absorption coefficients per meter for different wave-lengths and depths at Stations 47°26′—126°26′ and 48°24′—128°01′.

of light in controlling the diurnal migration of plankton. Although the available experimental evidence does not show a correlation between light intensity, or changes in intensity, and migration, Clarke (6) has some confirmatory evidence that light is the most important factor in controlling diurnal migration of some species in the Gulf of Maine.

The same variations in absorption coefficients appear if the values of the coefficients are plotted against depth for each spectral band. This is shown in Figure 6 for the station 48°24′—128°01′, and brings out clearly the increase in absorption in the region from 30 to 50 meters for all colors.

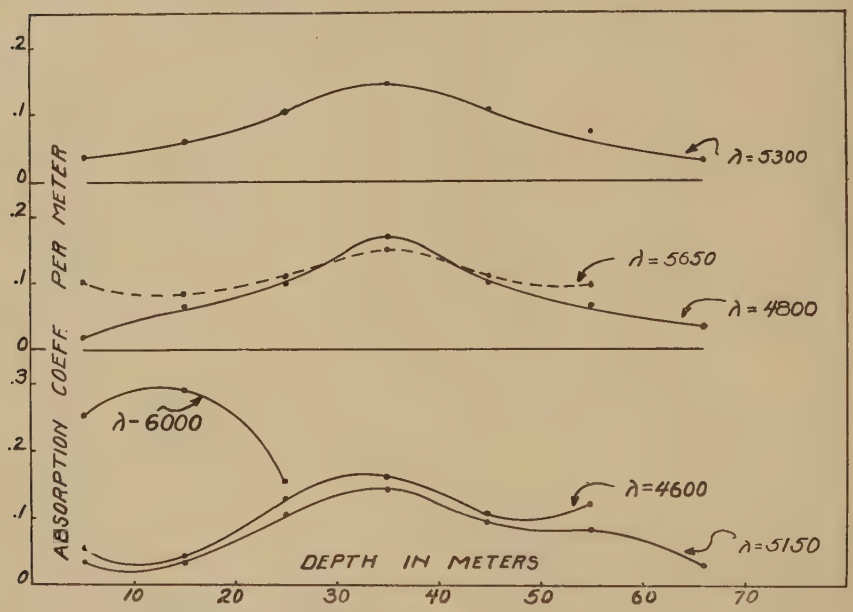

Fig. 6. Absorption coefficients for each color at Station 48°24′—128°01′.

Discussion.

There are inherent sources of uncertainty in measurements of the transparency of ocean waters which must be considered in drawing conclusions from the value of absorption coefficients.

The effect of the ship when the sea photometer is near the surface may be considerable. While making the observations in the Pacific, the ship, which had a medium dark grey hull, was always placed away from the position of the sun. The photometer was lowered over the side from a boom and was usually about two meters from the hull. All of the observations in the Pacific were made under a uniformly overcast sky. The light was well diffused and quite constant during the measurements.

In order to compare intensities at different levels or for different colors, it would be necessary to know that the column of water, and its contents, from the point under observation to the surface did not change during the measurements. Obviously this condition does not exist. The design of the device for shifting the filters reduces the time between observations to a few seconds, thus insuring a minimum change in the water above the photometer. Errors resulting from this cause are probably much greater in inshore waters than in the open sea. Atkins and Poole (2) estimate such error negligible at a distance of 10 miles from shore.

The value of the absorption coefficient is in part determined by the amount of suspended material. In the inshore waters a considerable part of the decrease in intensity is due to scattering from suspended particles, and the quality of the light most scattered depends upon the size of the suspended particles. Particles, in addition to scattering light, also absorb light. The absorption may be both general and selective. The effect of suspended matter in the water at the stations where these observations were made was apparently quite small. However, the effect of particle absorption and particle scattering contributes to quite an extent to the variation in the total vertical absorption coefficient.

The variation of the transmission band of the filters is a source of an uncertainty, because the absorption of the water is greater in the violet and red parts of the spectrum than in the middle portion. Thus the effect of absorption with increasing depth for a red filter is to cut off the transmission band from the long wave-length side. The reverse is true for a violet filter. Birge and Juday (7) employ filters which transmit all wave-lengths from the cut-off on the long wave-length side. They use the wave-length as that where the line of cut-off intersects the line representing fifty per cent. of the energy. The filters used in the present measurements had quite narrow transmission bands and the wave-length assigned to each filter was one determined by shifting the effective wave-length toward the region of greatest transparency of the water.

Table II shows the averages of the total vertical absorption coefficients obtained for the stations in the Pacific, one inshore station in the San Juan Archipelago, International Hydrographic Station E-1 (2), Gunflint Lake (8) in northern Minnesota, and the spectrophotometric results obtained at the Naval Research Laboratory (1). The values of the absorption coefficients of other experimenters were obtained by plotting their data and interpolating for the wave-lengths used in these experiments. It is very interesting to note the increase in the value of the absorption coefficient starting from Hulburt's value for pure sea water, thence for the open ocean, proceeding landward to the inshore waters and finally for inland lakes.

The open ocean stations, 49°22′—129°29, 48°24′—128°01′, and 47°26′—126°26′ were approximately 120 miles off shore. The values of the absorption coefficients at these stations are quite low, although not nearly as low as those for pure water. The average maximum

transmission at these stations is shifted slightly toward long wave-lengths compared with that for pure sea water. Station 49°25′—127°09′ was 28 miles from shore, while the work reported by Atkins and Poole was performed about 10 miles off shore. Here the maximum transmission, in the range compared, was slightly toward the short wave-lengths compared with that of pure sea water. The station at Thatcher Pass was located on the north side of the channel between Blakely Island and Decatur Island. The water here had a definite green color and at the time of observation was very rich in plankton. Table II shows that this water had its maximum transmission in the

Table II.

Comparison of Absorption Coefficients.

Observer	Total Vertical Absorbtion Coefficient Per Meter						
	$\lambda = 4600$	4800	5150	5300	5650	6000	6600
Hulburt 0—4 meters Spectrophotometer	.0166	.0154	.018	.024	.052	.165	
Utterback and Jorgensen Average of deep sea stations	.085	.073	.069	.079	.100	.253	.503
Utterback and Jorgensen Station 49° 25′—127° 09′	.104	.093	.106	.093	.122	.279	.574
Atkins and Poole Internat. Hydrographic Station E-1	.143	.146	.154	.157	.163	.224	
Utterback and Jorgensen[1]) Thatcher Pass, San Juan Islands	.336	.316	.258	.256	.288	.441	.593
Erikson Gunflint Lake, Minnesota	.820	.610	.437	.390	.321	.330	

[1]) Unpublished data.

Hulburt's values were obtained with a spectrophotometer with a 4-meter column of pure sea water. The averages in the second row are for three deep sea stations 120 miles west of the North American continent. The third row is averages at a distance of 28 miles west of Vancouver Island. The fifth row was obtained from inshore waters. The last row is given for comparison. The values of Hulbert, Atkins and Poole, and Erikson were obtained by interpolation of their data.

middle portion of the spectrum. The values of the total vertical absorption coefficient are considerably greater for such water than those for the off-shore waters. The high value of the absorption coefficients, compared to ocean waters, for inland lakes is no doubt due to differences in materials in solution and in suspension.

Summary.

The total vertical absorption coefficients, as here used, are found to be a good index of the transparency of the water. While sources of errors in the measurements are appreciable, the results are typical for the waters studied.

There is a definite and marked decrease in the transparency of the water proceeding from the open ocean to inshore and lake waters. This is true for all wave-lengths studied.

In the open ocean the red light is mostly absorbed in the first few meters leaving a deficiency of the red in the deeper waters.

The region of greatest transparency is in general in the blue in ocean waters. This is in contrast to the inshore waters, where the greatest transparency is in the green.

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An Exceptional Occurrence of *Rhizostoma octopus* and *Chrysaora hysoscella* in the Danish Waters in 1933.

By

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FIVE species of Scyphomedusæ are known from the Danish waters: *Aurelia aurita* (L.) and *Cyanea capillata* (L.), which are indigenous and locally very abundant, *Cyanea lamarcki* Pér. et Les., which occurs regularly along the west coast of Jutland in summer, and *Rhizostoma octopus* (L.) and *Chrysaora hysoscella* (L.), which are more rare visitors to the same coast. The distribution of the three last-mentioned species was rather peculiar in 1933.

Cyanea lamarcki is considered by some authors to be a mere colour-variety of *C. capillata;* it differs, however, from the latter not merely by its brilliant blue colour, but also in size and geographical distribution. *Cyanea lamarcki* is an inhabitant of the coastal waters of north-western Europe; it is common off the coasts of England, and at Heligoland it is the most abundant of all Scyphomedusæ. In this latter area it occurs from about the middle of May to the middle of September and may attain a size of about 15 cm. in diameter, though most specimens are only about 12 cm. It is undoubtedly indigenous in the Horns Reef area (off the southern part of the west coast of Jutland), and occasionally also farther north (on April 30th, 1931, I found a few specimens, 3—5 cm. in diameter at Hirtshals on the Skagerak coast), but the great swarms which are seen along the coast in the summer months probably originate from more southern breeding areas, whence they are carried northwards by the Jutland Current as far as the Skaw. From this point the Jutland Current proceeds eastwards towards the coast of Sweden, sending off a south-going branch as an undercurrent into the deep eastern channel of the Kattegat; but as a rule *Cyanea lamarcki,* being a surface-water medusa, does not join the south-going movement of the water; it is

rarely met with in the Kattegat. Even as far north as Hirtshals and the Skaw *C. lamarcki* is usually very abundant in July and August, but in 1933 I never saw it, though I visited Hirtshals several times. I have no information of its occurrence off the southern part of the west coast in 1933, but its complete absence from the Skagerak coast was really very striking.

Chrysaora hysoscella likewise belongs to the coastal waters of western Europe. It is fairly common in the English Channel and it is sometimes observed at Valencia Harbour (Ireland) and at Liverpool in June, July and August, but has never been recorded from Scotland. It is indigenous in the Channel and at least as far eastwards as the coast of Belgium, whence it is carried towards the north-east by the coastal-water current. As a rule it is common at Heligoland for a few weeks in September and October, but as far as we know it is very rarely met with further north off the west coast of Jutland. It is an established fact that, under normal conditions, pelagic organisms do not spread northwards from the German Bight. This is probably due to the cyclonic eddy which is almost always present in the surface water of the German Bight (Böhnecke 1924). According to some unpublished notes by D. Damas, *Chrysaora* has been observed off the west coast of Norway, but no precise data are at hand. The few records from Danish waters will be mentioned below.

Rhizostoma octopus is common off the Atlantic coasts of France and in the English Channel, where it is indigenous. Its occurrence off the Belgian coast is very irregular, and most probably it is not indigenous in the North Sea, but is carried in through the Straits of Dover. In a previous paper (Kramp 1930, p. 35) I have demonstrated that, in spite of the heavy tides, the medusæ which are carried through the Straits of Dover into the North Sea approach the coasts inside the straits only to a very slight degree. The ingoing Channel water with its content of medusæ and other pelagic organisms keeps itself in the middle of the area between the coasts of Belgium, Holland and England, and the resulting current proceeds south of the Dogger Bank towards the west coast of Jutland where it constitutes part of the so-called Jutland Current. *Rhizostoma octopus* belongs to this "Channel water", and as a rule some few specimens are observed off the west coast of Jutland and in the western part of the Limfjord in the autumn, but it rarely proceeds into the Skagerak. According to Hartlaub (1894, p. 200—201) *Rhizostoma* is not a constant visitor to Heligoland, though occasionally it may occur there in great swarms. In a letter of February 3rd, 1934, Dr. Cl. Künne, informs me, however, that *Rhizostoma* "pflegt hier (i. e., at Heligoland) im Laufe des Sommers zu erscheinen und verschwindet im Herbst wieder. Die Anzahl der Exemplare ist meist in jedem Jahre ziemlich gross". This means that specimens of *Rhizostoma* are caught by the Frisian coastal water current and carried into the German Bight in company with *Chrysaora*.

It is interesting to compare the occurrence of the two species in

different years. The variations in their occurrence must be supposed to be due partly to variations in the course and velocity of the currents, partly to the actual size of the stock of each species which, of course, varies from one year to another. Determination of the causality in each single case is difficult, because in most cases our information is very deficient. In the following I will try to give a hypothetical explanation of the occurrence of the two medusæ in Danish waters in recent years, particularly 1933, when both were exceptionally abundant.

As mentioned above, specimens of *Rhizostoma* are usually seen in the autumn off the west coast of Jutland and in the western part of the Limfjord, whereas *Chrysaora* is very rarely observed there, and normally none of them are carried into the Skagerak. For several years I have visited the new harbour at Hirtshals on the Skagerak coast at short intervals from early spring to late autumn, and I have never seen these medusæ until September 1933, when both were extremely abundant, and from the sayings of local people I daresay that this was an exceptional case. A similar case must, however, have occurred in 1896, when a swarm of both species passed through the Skagerak, crossed the northern entrance to the Kattegat, and appeared in the Gullmarfjord on the Swedish Skagerak coast in October and November (Aurivillius 1898). According to Aurivillius, *Rhizostoma* was observed in 1898 at Frederikshavn (northern part of the east coast of Jutland), and in the Zoological Museum of Copenhagen we have a specimen from Aalbæk (between Frederikshavn and the Skaw) taken in 1877 by V. Schmidt. On July 12th, 1916, I saw a specimen of *Rhizostoma* at the Biological Station at Drøbak in the Kristianiafjord; according to a letter from Hj. Broch this is the last time the species has been observed in Kristianiafjord, until some specimens appeared there in October 1933. A specimen of *Chrysaora* was taken north of the Skaw on October 28th, 1903, by the "Thor" (the specimen is in the Zoological Museum); this is the only record of this species inside the mouth of the Skagerak since 1896.[1])

In order to obtain information on the occurrence of *Rhizostoma* and *Chrysaora* at Heligoland in 1925, 1926, and 1930, when the latter species was observed off the west coast of Jutland, I wrote to Dr. Künne, who answered as follows (March 17th, 1934): "In unseren Aufzeichnungen über das Auftreten der Planktonten sind die Notizen über die beiden Medusen in genannten Jahren sehr spärlich. Es ist das ein Zeichen defür, dass nichts Aussergewöhnliches beobachtet wurde und dass die Medusen nicht auffallend zahlreich waren.... Auffällige Erscheinungen und Beobachtungen wären sicher notiert worden". (For details, see below.)

In September 1925 Dr. R. Spärck saw several specimens of *Rhizostoma* (but no *Chrysaora*) in the western part of the Limfjord

[1]) In "Preussische Provinzialblätter" 1848 *Chrysaora* is recorded from Danzig in the Baltic; in contradistinction to Vanhöffen (1903) I consider this record beyond the limits of probability.

Fig. 1.

▲ Rhizostoma octopus. Sept. 1925.
■ Chrysaora hysoscella. Oct. 1925.
● „ „ Sept. 26th—Oct. 2nd 1930.

(Nissum Bredning and Venø Bugt); it was unusually common that year. In the middle of October several specimens of *Chrysaora* (but no *Rhizostoma)* were found in five localities south and south-west of the Horns Rev (see map, Fig. 1). In 1925, accordingly, both species were common off the west coast of Jutland, but in two separate areas. At Heligoland *Rhizostoma* was not particularly common (one fairly small specimen was found in July, and several specimens were observed on August 25th, according to a letter from Dr. K ü n n e). *Chrysaora* was fairly common as early as July, when specimens of all sizes from 8 mm. in diameter were found. This is very interesting, as it shows

Table I.

Aberrations of salinity in ‰ at the Horns Rev lightship in each month of the years 1925, 1926 and 1930.

	1925		1926		1930	
Depth m. ..	5	30	5	30	5	30
I	0.1	0.0	*—0.6*	*—0.5*	1.2	1.0
II	0.2	0.1	*—0.6*	*—0.2*	0.8	0.9
III	0.2	0.3	*—0.9*	*—0.7*	0.6	0.3
IV	0.2	0.0	*—1.3*	*—1.1*	0.6	0.5
V	*—0.4*	*—0.2*	*—1.4*	*—0.6*	0.8	0.8
VI	0.0	0.3	*—0.6*	*—0.3*	1.0	0.8
VII	0.4	0.1	*—0.6*	0.0	0.4	0.4
VIII	0.0	*—0.1*	*—0.4*	*—0.4*	0.6	0.3
IX	0.2	0.0	*—1.1*	*—0.9*	0.4	0.2
X	0.1	*—0.1*	*—1.3*	*—0.4*	0.8	0.8
XI	*—0.5*	*—0.1*	*—0.6*	*—0.3*	0.8	0.6
XII	*—0.8*	*—0.6*	*—0.6*	*—1.1*	*—1.0*	*—0.4*

that in this summer the species was indigenous in the German Bight, whence the stock was spreading northwards as far as Horns Rev. The salinity of the water at the Horns Rev lightship (see Table I) was very nearly normal throughout the year and there is nothing to indicate that the occurrence of *Chrysaora* south of Horns Rev was due to any peculiar conditions of the currents. The abundance of *Rhizostoma* further north was most probably due to hydrographical conditions which had no connection with the distribution of *Chrysaora*, so that the occurrence of the two species in 1925 were independent phenomena.

We have no information on the occurrence of *Rhizostoma* and *Chrysaora* at Heligoland in 1926; on October 7th a large specimen of *Chrysaora* was found near Tyborøn at the western entrance to the Limfjord. During the summer of 1926 a considerable influx of water took place from the North Sea through the Kattegat into the Baltic, as evidenced by a remarkable increase in the salinity of the bottom water in the Belt Sea, whereas in the Kattegat the salinity was not particularly high, which indicates that the inflowing water came from the southern and not from the northern part of the North Sea. This accords well with the fact that the salinity at Horns Rev was below the normal throughout the year (see Table I). Probably the Jutland Current consisted mainly of Frisian coastal water of low salinity, which carried *Chrysaora* far towards the north along the west coast of Jutland.

On November 20th, 1929, a very large specimen of *Rhizostoma* was found near Frederikshavn on the east coast of Jutland; it measured 50 cm. in diameter.

In the autumn of 1930 I took part in a cruise with the "Dana" in the North Sea. On September 26th two specimens of *Chrysaora* were found north of Hanstholm, and on subsequent days this beautiful medusa was observed in great abundance in the neighbourhood of the

Fig. 2.

▲ Rhizostoma ● Chrysaora. 1933.

Jutland Reef and the Little Fisher Bank (see map, Fig. 1). Many were caught in the ringtrawl with 50—100 m. of wire out, and several were also seen swimming at the surface in the smooth water in the bright sunshine. The specimens varied in size from 3 to 12 cm. in diameter. *Rhizostoma* was completely lacking, but on the Little Fisher Bank (about 6° E.) several large *Cyanea capillata* were seen. The ship proceeded towards the south-west to the Dogger Bank, but not a single specimen of *Chrysaora* was observed west of Lat. 6° E., whereas *Cyanea capillata* was very abundant on the Dogger Bank. On October 2nd, while returning towards the coast of Jutland on Lat. 55°33′ N., I keenly awaited the moment when we should see *Chrysaora* again, and as soon as we had passed Long. 6° E. the medusa was met with

once more in great abundance. In this area there were specimens of all sizes from 3 cm. up to 24 cm. in diameter. Here also *Rhizostoma* was not found. At Heligoland the first specimen of *Chrysaora* was observed on July 24th, and a few *Rhizostoma* were taken on September 17th.

The salinity at Horns Rev (see Table I) was a little above the normal throughout the year in 1930 (except in December). It is not very probable, therefore, that the stock of *Chrysaora* observed off the west coast of Jutland came from the German Bight. I would rather explain the distribution of *Chrysaora* and the absence of *Rhizostoma* in the following way: The "Frisian coastal water" probably deviated from the coast rather far to the west and moved northwards at a considerable distance from the coast of Jutland so as to escape to a great extent the usual eddy in the German Bight, carrying with it a stock of *Chrysaora* which at the end of September had reached as far as the western part of the Skagerak. The "Channel water", on the other hand, did not follow, which may account for the scarcity of *Rhizostoma;* the apparently inconsiderable distribution of the Channel water may even have been the reason for the remarkable deviation of the Frisian coastal water.

In 1933 *Chrysaora* and *Rhizostoma* were exceptionally abundant in Danish waters, and specimens of both were even observed in the Kattegat (see map, Fig. 2).

Dr. Künne (Heligoland) has kindly given me the following information on their occurrence in the German Bight: *Rhizostoma:* "Im Jahre 1933 trat sie besonders früh auf; bereits Ende Juli—Anfang August wurden einige beobachtet. Mitte August wurde sie vor der Elbe-Mündung zahlreich angetroffen. Im September waren bei Helgoland sehr viele in allen Grössen. Mitte dieses Monats waren Ost von Helgoland viele grosse Exemplare zu finden, desgleichen vor der Weser-Mündung. Direkt in Menge konnten sie in der zweiten Hälfte des September an mehreren Tagen zwischen Helgoland und der Elbe-Mündung beobachtet werden; die Meduse war hier so zahlreich, dass ich auf einer Reise bei jedem Blick vom Schiff aus mehrere Individuen sah. Aus allen vorliegenden Beobachtungen geht hervor, dass *Rhizostoma* im Sommer 1933 in der Deutschen Bucht besonders häufig war." *Chrysaora:* "Im Sommer 1933 hatte es ... den Anschein, als ob *Chrysaora* weniger häufig sei. Sicher ist, dass ihre Anzahl nicht grösser war als in anderen Jahren."

On September 5th Mr. Heegaard, on board the S.S. "Dana", observed *Chrysaora* north-west of Horns Reef, and the next day he saw *Rhizostoma* swimming in Esbjerg harbour.

In September Dr. E. M. Poulsen (Danish Biological Station) saw many *Rhizostoma* (up to 40 cm. in diameter) and some specimens of *Chrysaora* in the western part of the Limfjord (Nissum Bredning, not further east in the Limfjord).

On September 4th Professor M. Thomsen (Copenhagen) came to Hanstholm at the entrance to the Skagerak; it was a fine day

with sunshine and calm water, and from the harbour pier he saw numerous medusæ of both species being carried along by the current, and he took some fine photographs which he afterwards showed me.

From Hirtshals, further east in the Skagerak, I have the following observations. On September 2nd I found some fragments of *Rhizostoma* on the sandy beach west of the harbour. On September 12th—13th I saw several beautiful specimens of *Chrysaora* swimming in the harbour, whereas *Rhizostoma* was not seen there; on the beach west of the harbour, on the other hand, numerous large specimens of *Rhizostoma* (up to 42 cm. in diameter) were stranded. The sea was calm, but, shortly before, the weather had been fairly rough; it is peculiar that the surf had thrown many *Rhizostoma* but hardly any *Chrysaora* on shore; the latter, being a fairly active swimmer, was evidently the more resistant of the two, whereas *Rhizostoma* was helpless when it came so near the shore as to be caught by the heavy breakers.

One of the harbour engineers, Mr. B o r n e r, watched for the occurrence of the medusæ after this date. On September 30th *Chrysaora* was still common in the harbour, and *Rhizostoma* was found cast ashore. On October 5th some *Rhizostoma,* 20—35 cm. in diameter, were seen in the harbour on a stormy day (hard wind from N.W.), and the next day a very large specimen (about 45 cm.) was observed swimming in the harbour. From that day both species disappeared. On October 24th I visited Hirtshals again; persistent easterly winds had caused west-going currents and very low water; I only found 4 specimens of *Rhizostoma,* badly damaged, cast ashore some distance west of the harbour.

When I first observed the medusæ at Hirtshals, I wrote to a fisherman at Frederikshavn, H e n r y N i e l s e n, a reliable man and a keen observer, describing the animals to him and begging him to look out for them, and on October 14th and 15th he saw a few specimens of both species near Frederikshavn. This seems to have been the limit of the progress of *Chrysaora,* whereas *Rhizostoma* continued its way in different directions.

In the Swedish periodical "Fauna och Flora" (Heft 5, 1933, p. 204) E. L ö n n b e r g and G. G u s t a f s o n give an account of the occurrence of *Rhizostoma* at the Kristineberg Zoological Station in the Gullmarfjord on the Swedish Skagerak coast in 1933. In September (date not stated) a few specimens were seen in the harbour of the station; later on the species increased in number, and on September 26th more than 30 specimens were found cast ashore in the neighbourhood of the station, and in the fjord the medusa was seen in great abundance. "Anything like this has certainly never been observed there before".

Rhizostoma also came into Kristianiafjord, though apparently only in small numbers. Dr. H j. B r o c h (Oslo) tells me in a letter (Jan. 25th) that two specimens were taken at the biological station at Dröbak late in October, and in the inner part of the fjord, not far from Oslo, a specimen was seen in the middle of December.

Rhizostoma also penetrated far into the Kattegat. Mr. Hj. Ussing (Randers) has sent me a fragment of a large specimen (about 40 cm. in diameter) which was caught by a fisherman at the mouth of Randersfjord on October 25th. Another specimen was caught at Havnsö in the Sejröbugt (north-west coast of Seeland) on October 23rd, and in November our museum received two specimens, both in excellent condition, taken at Tisvilde on the north coast of Seeland on November 21st. Since the finding of a specimen of *Rhizostoma* at Kiel in 1873 (Möbius), this is the first time this medusa has penetrated so far into the Danish waters.

Table II.

Aberrations of salinity in ‰ at various Danish lightships in each month of the year 1933.

Lightship	Horns Rev		Skagens Rev		Anholt Knob		Schultz' Grund	
Depth m. .	5	30	5	38	5	28	5	26
I	0.7	0.7	*—0.3*	0.2	*—3.0*	1.2	*—3.1*	2.7
II	1.4	1.2	0.5	0.0	*—0.4*	1.5	0.3	1.7
III	0.5	0.6	0.4	0.1	*—3.1*	1.1	*—1.7*	1.4
IV	0.7	0.6	1.9	*—0.1*	1.8	0.7	2.2	0.3
V	0.1	0.4	2.1	0.2	*—0.6*	0.3	*—0.9*	0.3
VI	*—0.4*	0.4	0.5	1.0	*—4.3*	0.9	*—2.8*	1.0
VII	*—0.3*	0.2	1.1	*—0.1*	1.4	1.8	*—0.3*	1.1
VIII	*—0.2*	*—0.3*	0.9	*—0.4*	3.2	0.9	2.6	*—0.1*
IX	0.2	0.1	*—0.6*	0.8	*—0.5*	1.0	*—1.7*	*—0.8*
X	0.2	0.2	*—0.7*	0.2	*—0.2*	1.2	*—1.0*	1.1
XI	0.2	0.1	*—2.6*	0.1	0.5	1.2	*—0.8*	*—1.6*
XII	0.4	0.4	*—5.5*	0.1	*—2.2*	1.9	*—1.7*	*—0.1*

Chrysaora hysoscella and *Rhizostoma octopus* were not the only pelagic animals which had a peculiar distribution in the Danish waters in 1933, and from the knowledge of the occurrence of certain other species in connection with the hydrographical observations from the lightships we can draw some conclusions concerning the movements of the waters during this peculiar year.

In Table II are given the aberrations of the average salinity for each month in 1933 at the bottom and 5 metres below the surface at some of the Danish lightships. At the Horns Rev lightship the salinity was generally a little above the normal, but the aberrations are very small. At "Skagens Rev" there were rather considerable variations in the salinity of the surface water, whereas the mean values do not show any noticeable aberrations in the bottom water; the maximal values observed are, however, frequently very high (salinities of more than 35 ‰ were observed almost every month), which indicates that water from the deeper strata of the Skagerak rose towards the coast, at least on occasions. At "Anholt Knob" in the eastern part of the Kattegat the salinity of the bottom water was rather considerably above the normal throughout the year, and maximal values between 34 and

35.1 ‰ were observed every month. During the first three months of the year very high salinities were also observed at the bottom at "Schultz Grund" in the south-western part of the Kattegat, whereas the surface water generally had a low salinity at "Schultz Grund" as well as at "Anholt Knob". Evidently there was a considerable drift of very salt water from the deeper strata of the Skagerak towards the north-west coast of Jutland and into the deeper parts of the Kattegat, and sometimes this water even came close to the east coast of Jutland, at least in the neighbourhood of Frederikshavn. In March Mr. Henry Nielsen saw a dense swarm of the ctenophore *Beroë cucumis* in shallow water near Frederikshavn, and from the middle of July to the beginning of August, when persistent and rather strong westerly winds caused remarkably high water in this part of the Kattegat, young specimens of the pteropods *Clione limacina* and *Limacina helicina* were abundant in the plankton. The rare, almost exceptional, occurrence of these organisms at Frederikshavn strongly confirms the above statement of an uncommon uprising of the deeper water layers of the Skagerak, of which these animals are constant inhabitants, and the phenomenon had already commenced at the beginning of the year and lasted until August. This rising of the Skagerak water probably barred the way of the Jutland Current and kept it back for a long time, which may account for the absence of *Cyanea lamarcki* on the Skagerak coast during the summer (see above).

Towards the end of August conditions entirely changed. The Skagerak water retired and gave way to the Jutland Current which now rushed forward along the coast of Jutland carrying with it the large stocks of *Rhizostoma* and *Chrysaora* which had accumulated in the southern parts of the North Sea and been thoroughly mixed there; now they came northwards together. Both species were abundant at Hanstholm at the beginning of September; at the same time some few specimens of *Rhizostoma* had reached as far as Hirtshals, but some days elapsed before the bulk of the specimens of both species arrived there. *Chrysaora* hardly reached beyond the Skaw, but towards the end of September the great stock of *Rhizostoma*, preceded by a few precursors, appeared on the Swedish coast, and during the following months single specimens penetrated southwards into the southern Kattegat and northwards into the Kristianiafjord. Apparently the great majority of the individuals of both kinds of medusæ travelled together, but preceded by some stray specimens of *Rhizostoma* (in Nissum Bredning in the Limfjord also a single *Rhizostoma* was observed some days before both species became common there), which confirms my supposition that they had accumulated somewhere in the southern part of the North Sea (in the German Bight and perhaps elsewhere too), until the withdrawal of the Skagerak water permitted the Jutland Current to rush along with uncommon velocity.

I must mention further that according to a recent paper by Mrs. Ellen Thomsen (March 1934) a living specimen of *Sepia officinalis* was found south of the Skaw on June 30th, 1933. This

was long before the Jutland Current, in my opinion, began again to flow, carrying the jellyfish with it, and the unique find of this cephalopod in Danish water must, therefore be an outcome of the rising of the Skagerak water, for which we have the evidence mentioned above.

I wish to thank Dr. Cl. Künne, Heligoland, Dr. Hj. Broch, Oslo, and Dr. H. Blegvad, Copenhagen, for valuable information on the occurrence of *Chrysaora hysoscella* and *Rhizostoma octopus* in 1933 as well as in other years.

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Lunar Influence on the East Anglian Herring Fishery.

By

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THE instability of the yield from year to year is a characteristic common to all the North Sea fisheries, and biological research into the life history of any of the food-fishes should ultimately develop into a study of the many causes of this instability or fluctuation.

In the case of the herring, or indeed any of the "seasonal" fishes, there are many kinds of fluctuation, just as there are many causes, and in general, the changes in the yield may be divided into two groups, firstly, those which take place over very long periods, and secondly, those which happen spasmodically from year to year, month to month, or even from day to day.

If one examines the total landings of herrings for each year at Lowestoft and Yarmouth since 1912, it will be seen that there are enormous differences in the yield of some years compared with others, but tables of total landings show only the effect of every kind of fluctuation, and from them it is impossible to determine what influence any one phenomenon has on the catch. There are two main causes of variation in the same way that there are two kinds of variation. These may be called natural and artificial, and it would be difficult to say which has the greater influence on the total landings of herrings. The actual numerical strength of the individuals which make up the herring stock is known to vary from year to year, owing to the fact that the losses due to capture and natural mortality may not be adequately compensated by the new brood which joins the shoals each year, and further, it is to be expected that the herring is quite sensitive to changes in the medium in which it lives, so that variations in temperature, salinity and movements of the water may at some time be instrumental in causing the fish to behave in a manner detrimental to the fishery. Research into the plankton content of the areas where herrings are found, has shown that while the fish

may congregate on grounds where they find a concentration of copepods, they will be diverted from grounds where there are to be found concentrations of diatoms, and the occurrence of phytoplanktonic organisms in the southern North Sea has, during the past ten years, been definitely associated with irregularities in the migration of the herrings. Changes in the fishery which are caused either by variation in the brood strength, or by migration due to different environments are natural fluctuations, and so far as our present knowledge goes, can be called capricious variations.

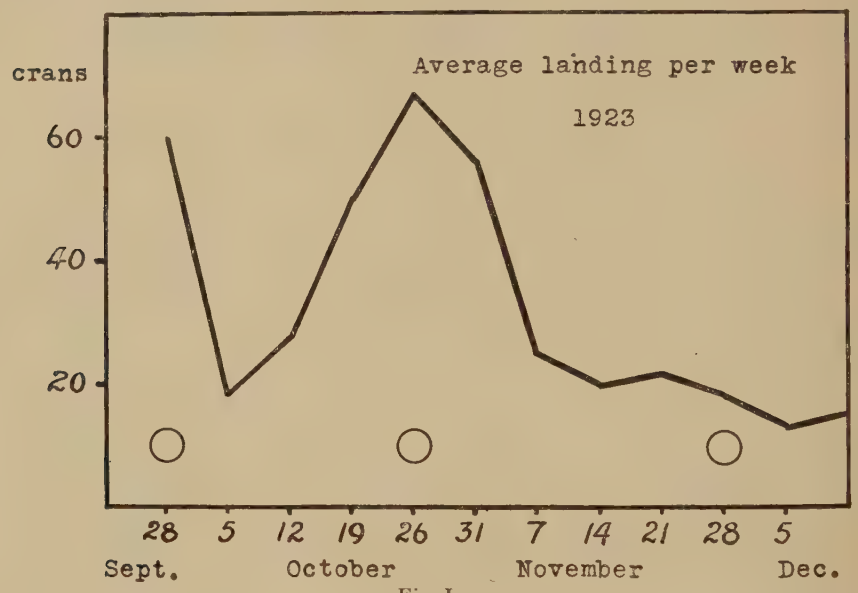


Fig. I.

Artificial variations in the total landings of fish are also capricious, and may be caused by wars, strikes, loss of markets and weather, in fact by anything which will interfere with the normal activities of a fishing fleet.

Genuine periodic or rhythmical variations in the herring fishery are difficult to find, although during the seasons 1923 to 1933 certain cases have been observed. A study of the age-composition of the shoals from East Anglian grounds has shown that the broods of the years 1915, 1918, 1921, 1924 and 1927 were all above the average. Here it will be seen that there is a three-year period between good year-classes.

In 1923, at the beginning of the herring investigations, one of the first things to be learned of the herring fishery was that catches were always expected to be better "at the full of the moon" than at the period of new moon, so at the end of the season this statement

was tested by drawing a diagram showing the average catch per vessel for each week of the fishery. The figure is reproduced above, and from it, it is gathered that there is certainly some connection between the phases of the moon and the catch of the drifters.

This curve shows a definite rhythm in the amount of fish landed throughout the period, and in September and October the peaks correspond with the weeks in which the full moon occurred. The November peak appeared during the week ending the 21st, while the full moon was on the 23rd, but in spite of this slight discrepancy the figure suggested that this change in the landings was a fluctuation worthy of further consideration.

During the thirteen seasons 1921 to 1933, the amount of herrings landed daily at the two ports Yarmouth and Lowestoft has been recorded, and these daily landings form the basis on which the following tables and figures have been built.

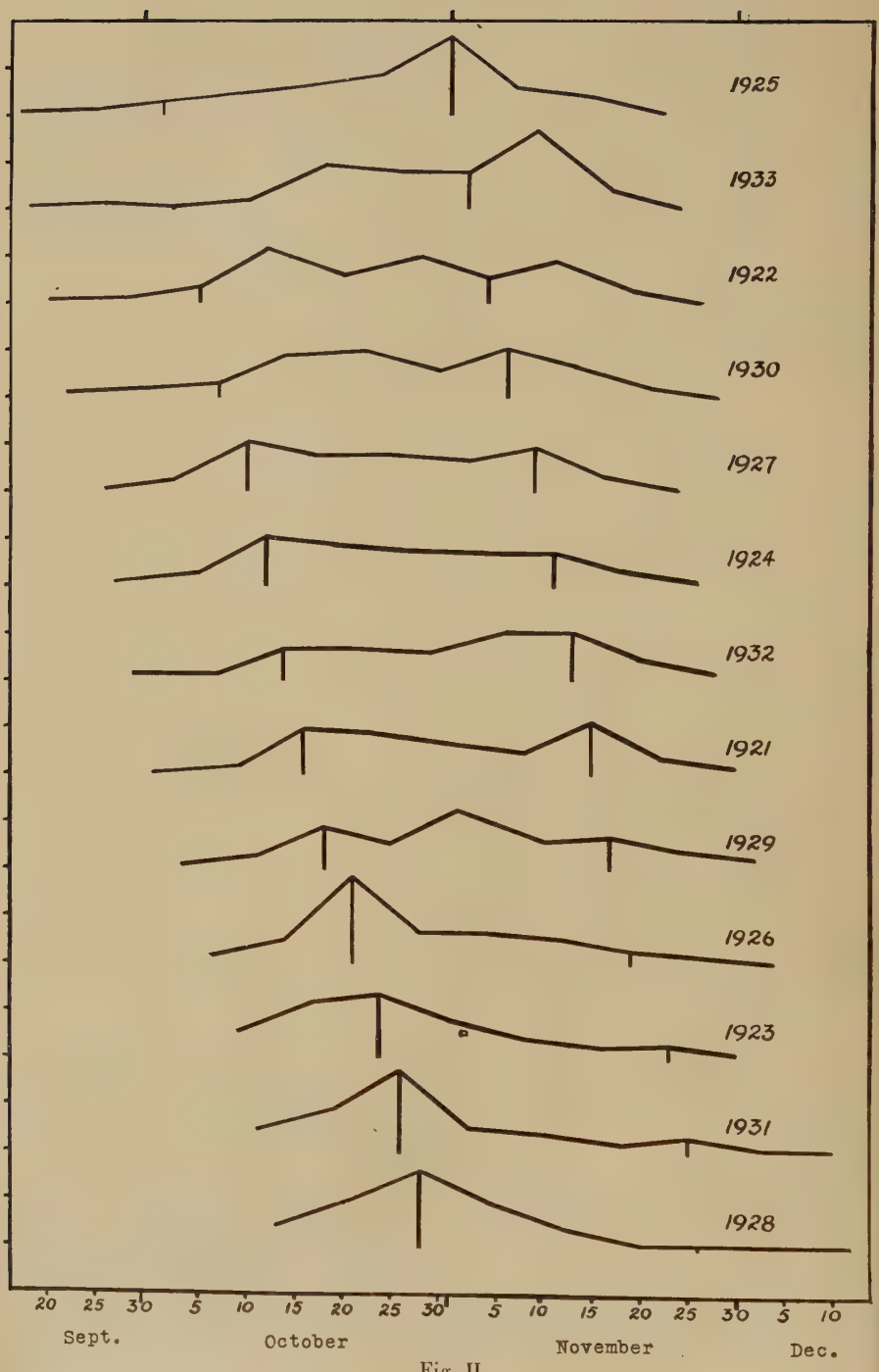
Table I, which contains all the available data for the period mentioned above, was drawn up in the following way: The various seasons have been divided into seven-day periods, using the date of the October moon and the date of the November moon as mid-points of two of these periods. Thus, in 1925, the full moons occurred on the 2nd and 31st of October, so the seven-day periods of which these dates are the mid-points will be September 29th to October 5th, and October 28th to November 3rd. It will be seen that in calculating backwards and forwards from these two periods it becomes necessary to omit occasional odd days to balance the periods. These days are shown singly in separate columns. The seasons having been divided into suitable periods, the total landing of herrings was found for each of these periods from the returns of daily landings, and this total landing (in crans) is shown in the table below the date in each column. Above the date, in italics, is shown the percentage of the total seasonal landing which was caught in each period. The dates of the full moons are shown in heavy type and the years are arranged according to the dates of the October moon, 1925 being first, as this occurred on the 2nd of the month, and 1928 being last with the moon occurring on the 28th.

From this table, Figure II has been constructed.

The percentage of the total catch taken in each seven-day period has been plotted on a time scale, the years being in the same order as in Table I, and perpendiculars have been drawn to show the percentage of the season's catch taken during the periods containing the date of the full moon as mid-points.

The general impression one has of this figure is that the height of the perpendiculars representing the catch at the October full moon gradually increases throughout the period of years as the date of the full moon becomes later in the month. On the other hand, the perpendiculars representing the catches at the November full moon gradually decrease.

It will be seen that in most years, one or both full moons correspond


1925
1933
1922
1930
1927
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1932
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20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
Sept.
October
November
Dec.

Fig. II.

to a definite rise in the catch, but in other years, 1933, 1922, and 1929, for instance, there is a peak in the landings during the inter-lunar period. These anomalies are the result of circumstances which have a greater influence on the landings than the moon, and may be described thus:

1933. This year was characterised by an unusual phyto-plankton concentration in the North Sea, its effect being to delay the appearance of the fish. The general absence of herrings on the well-known grounds caused the drifters to explore the more remote grounds of the East Anglian area, with the result that the whole fishery was spasmodic, and the landings very irregular.

1922. At the beginning of this season, there was much doubt and uncertainty in the minds of boat-owners, for, not only were they suffering from the disastrous effects of the 1921 season, but in addition, the Russian market was still unpromising and the German mark was rapidly falling. Preparations for fishing were only made on a small scale and a very much reduced fleet began the season. Later in October the gloom began to disappear, and at the time when good catches should have been made a series of gales, lasting for a fortnight, seriously interfered with the fishing, and caused a drop in the landings at the time of the November moon.

1929. The inter-lunar peak in the catch of this season is probably an artificial one, caused not so much by a glut of fish during this period as by a great reduction in the catching power of the drifter fleet at the period of the November full moon. It will be remembered that just after large catches were being made at the beginning of November, a very severe gale swept the area on November 11th, causing some 31,000 nets to be either lost or spoilt. The reduction in catching power had the effect of lowering the height of the November full moon peak, and thus to some extent accentuating a false peak between the two moons.

From Figure II, then, it is apparent that the distribution of the landings throughout the season's fishing depends on the date on which the October full moon occurs, and that the characteristics of the seasons, so far as landings are concerned, are constantly changing from one year to another.

With the exception of the years mentioned above, when greater influences than the moon upset the rhythm in the changes in quantity of fish landed, the success of the fishery seems to depend on the amount of fish caught during the two lunar maxima, so, from the preceding figure and Table I, the optimum conditions for a good fishery can be calculated.

The percentage of the total catch for each year, which was taken at the October full moon, has been plotted on a time scale, and a curve drawn through the points. Next, the percentage caught at the November full moon corresponding to each of the October moons was plotted and a second curve produced. Now, by adding these two

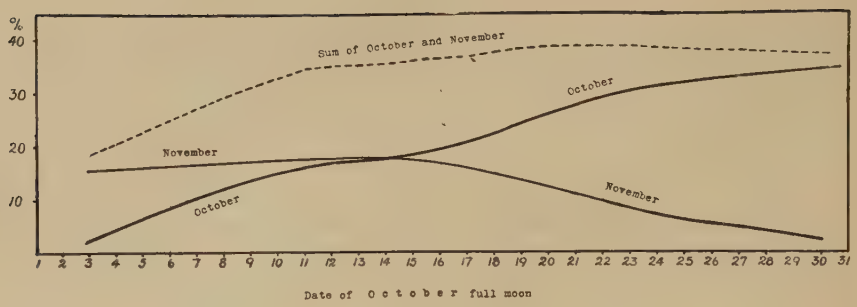


Fig. III.

curves, a third can be drawn showing the percentage of fish taken at the two lunar maxima combined.

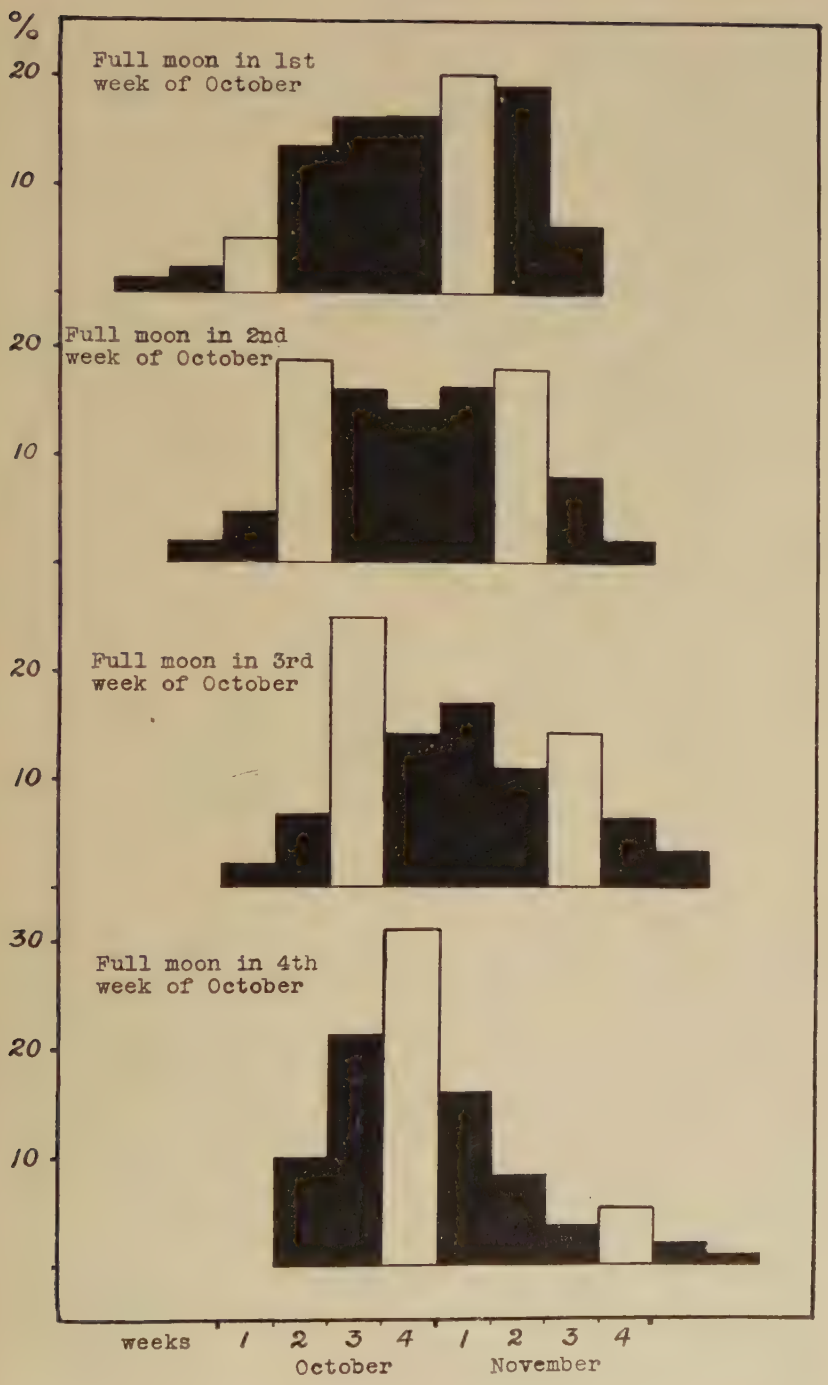
This has been done in Figure III and the curves for the October and November moons were drawn after the method described by Wollaston (7), by combining the points into triangles and finding the centre of gravity of each of these, and then drawing the smoothed curve through these centres of gravity. The curve showing the sum of the two lunar peaks rises rapidly from the beginning of October to the 11th, after which date it remains more or less constant. Thus it appears that the greatest effect of the two peaks together is felt when the Ocober full moon occurs after the 11th of the month.

We can now examine the average weekly landings of seasons with different lunar characteristics, in another way. In Figure IV the seasons have been grouped according to whether the October full moon occurred in the first, second, third or fourth week, and the histograms show the average weekly landing at Lowestoft and Yarmouth.

The effect of an early moon is clearly seen. In this case it is the middle and latter part of the season which produces the good catches, and the landings increase each week, to culminate in a peak during the week of the November full moon.

In the second case, the two maxima are almost of the same magnitude, and the bulk of the catch occurs in the middle of the season. A full moon in the third week of October produces a more pronounced peak for this period and the corresponding November moon is considerably less effective. The inter-lunar peak in this instance is due entirely to the year 1929 which falls in this collection of seasons, and a possible explanation of this has already been given.

The last type, when the full moon is during the fourth week of October, is of special interest, and differs from all the preceding cases. Here the late October moon coincides with a large peak in the catch and the late November moon produces a maximum so slight as to be of little value to the fishery. In seasons like this, there is but one period when catches are likely to be heavy, and after this there is a rapid drop in the size of the landings. It thus follows that if the fishery is hampered by severe gales during this critical fourth week,


%
20
10
Full moon in 1st week of October
20
10
Full moon in 2nd week of October
20
10
Full moon in 3rd week of October
30
20
10
Full moon in 4th week of October
weeks 1 2 3 4 1 2 3 4
October
November

F IV.

the chances of success will be reduced to a minimum. If the date of the full moon is during the first half of October, there seems to be, from the above figure, a possibility of five weeks of fairly even and constant fishing, but if the full moon is in the second part of the month, the fishing is likely to be concentrated into a shorter period, after a late start.

Before leaving the discussion of these seasonal groups, the peculiar case of 1925 must be mentioned. This year had both the "fishing moons" in October, the first on the 2nd and the second on the 31st, and therefore it should appear in Table I both as the first season and the last, but as the standard has been taken to be the October moon in order of date, it has only been included as the first of the series. The weekly landings of 1925 are shown in Figure V.

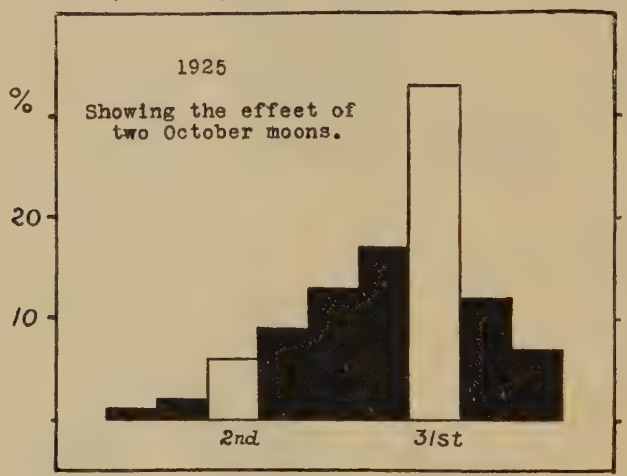


Fig. V.

The landings in this year are not distributed in the same way as in the case of seasons in which the full moon occurs in the first week of October. There is, instead, a gradual increase in the catch from the beginning of October until the second full moon when there is a very pronounced maximum, after which there is a rapid decline. It is clear from the above diagram that the season 1925 has characteristics which are more akin to those of years having the full moon in the fourth week of October, than to those in which the moon occurs in the first week. At any rate, the landings of 1925 emphasise the fact that an early October moon has the effect of producing the heaviest catches towards the end of the month.

The occurrence of peaks in the curves of total landings during the weeks of full moon is surely more than coincidence, but the finding of an adequate explanation of why such a thing happens impresses upon us the fact that there are points in herring behaviour which are not fully understood.

The moon itself has long been associated with phenomena which

affect living organisms, both plant and animal, and in some cases the association has been based on fact and in others on superstition. The regularity of the waxing and waning of the moon has been thought to influence growth, and Fox (2) gives many instances of this belief in relation to the growth of children, of wool on sheep, and even of human hair! This author deals also with the strange cases of the sea-urchins of the Red Sea, and the Palolo worm of Fiji, the former spawning at the time of full moon, and the latter almost exactly at the time of the last quarter.

In attempting to account for the moon's influence on living creatures, one is always encountering stumbling blocks. For instance, as the sea-urchins of the Mediterranean Sea do not exhibit the same characteristics as those of the Red Sea, it may be thought that the lack of any great tidal effect in the former area may to some extent account for the difference. Why, then, is no lunar rhythm observed in the British sea-urchins, although the tidal rise and fall is generally greater than in the Red Sea?

Little is known of lunar periodicity in fishes. The California Smelt which spawns between March and June comes into the coastal waters for this purpose. Thompson (6) states that they come at night, *and only on the three nights following each full moon.*

Hickling (4) finds a certain degree of periodicity in Hake catches, and shows that during the spring and summer the peaks occur at lunar intervals but not necessarily at full moon.

Desbrosses (1), on the other hand, in dealing with Dorade commune *(Pagellus centrodontus)* or Sea Bream, discovers a lunar rhythm, but in this case the peaks coincide with the appearance of the new moon.

In 1907 the Scottish Fishery Board (8) mentioned the influence of the moon on catches of herrings at Inverary. Tables showing the weekly landings from 1860—1900 are given, but the conclusions drawn from them are by no means definite. The total amount of herrings caught at new moon is greater than that taken at full moon, and the report states that moonlight is probably the chief factor, since the fish are able, on moonlight nights, to see the seines and thus avoid capture. On account of this, it often happened that on moonlight nights the fishermen did not put to sea, and this fact alone would render the tables of landings of little value.

From recent enquiries made concerning the Scottish fisheries, it appears that, while preference may be shown for certain states of the tide when drift fishing (just as in England), there is no evidence of the "full moon peaks" in the catches as in East Anglian waters.

In August and September, however, the Scottish fishermen like a full moon, but for a different reason. At this time the sea is highly phosphorescent and the moonlight tends to reduce the effect of this phosphorescence on the nets.

Tentative observations on lunar periodicity have been made at North Shields and Grimsby, but the results are not yet conclusive.

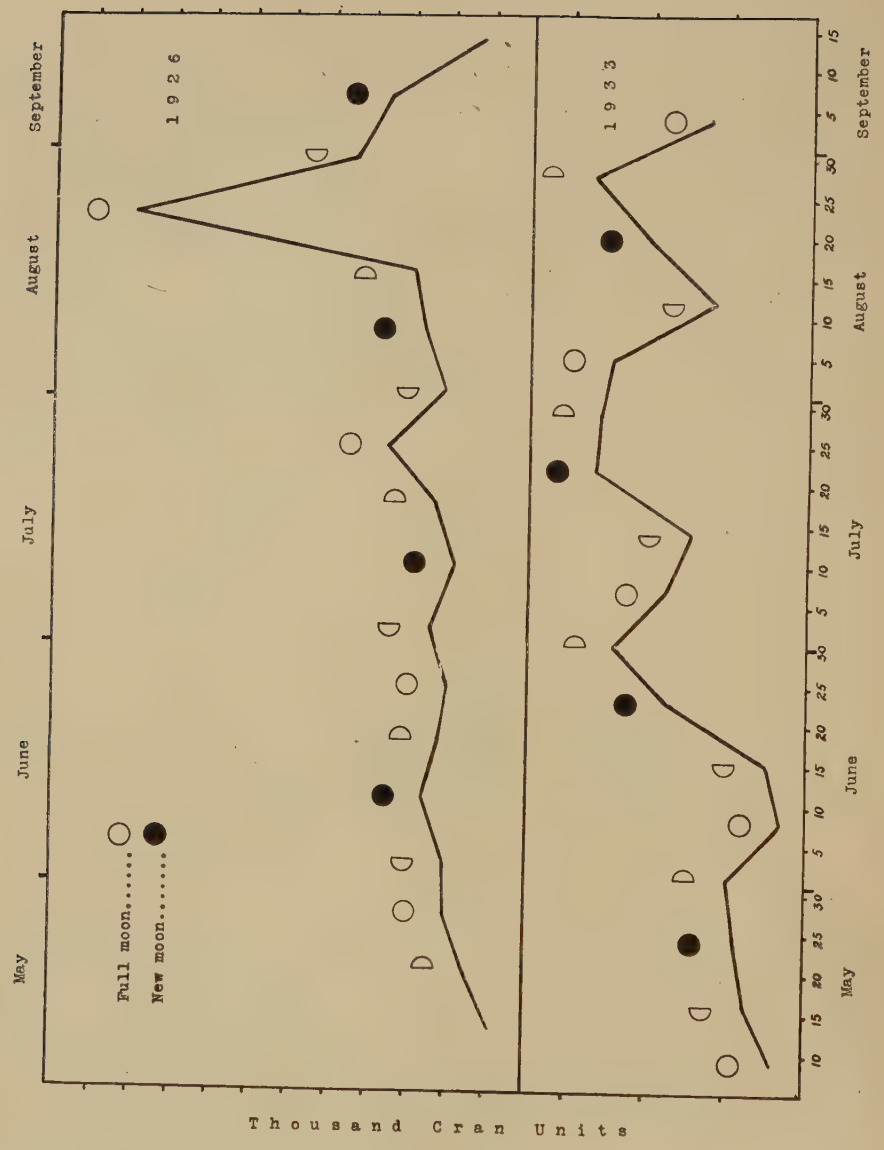


Fig. VI.

The landings of herrings at North Shields in 1933 exhibited a monthly rhythm during the months June to September, but the peaks in the curve appeared during the week of "first quarter" instead of at full moon. In 1926, the landings during the months of May and June were very irregular, and exhibited no apparent rhythm, but the periods of the full moons of July and August (particularly the latter) were marked by pronounced peaks in the landings. These two seasons

were very different, and in 1926 the total landings were considerably greater than in 1933. The high peaks at the times of the full moons of July and August 1926 would be caused by a great influx of mature fish which would be older than those present on the grounds during the earlier parts of the season, so it may be that the large numbers of these mature fish responded to the full moon influence in the same way as the mature herrings do in the East Anglian area.

The landings for 1926 and 1933 at North Shields, and the phases of the moon are shown in Figure VI.

In 1931 and 1932, no regular rhythm was observed at Grimsby, although in 1931 the main peak of the fishery occurred during the week of the September full moon, but, as the results of 1932 were quite different, this may have been brought about by chance.

The German fishermen, it is said, believe in the powers of the full moon to produce good catches, but no actual data are available. In cases where they have made poor catches they will expect to do better when the moon is full, so, whether they actually believe this will happen or whether they merely hope it will do so, is doubtful. To sum up the findings concerning lunar periodicity in fishes we have the following definite facts:

(1) **The Californian Smelt** comes inshore to spawn on the three nights following the full moon.

(2) The landings of **Sea Bream** at La Rochelle show fluctuations at certain times of year, the peaks corresponding to the period of new moon.

(3) **The Hake** catches show a lunar rhythm (that is, a monthly rhythm), but the peak catches may not necessarily be at the full moon.

(4) The North Shields herrings in 1933 exhibited a monthly rhythm, the peaks appearing during the week of "first quarter". In 1926, "full moon" peaks appeared in July and August.

(5) The East Anglian herrings have for many years (with minor exceptions) shown a lunar periodicity in the landings, the peaks being at the time of full moon.

How can these facts be explained? The outstanding effects of the moon's rotation round the earth are tides and moonlight, and immediately one would naturally look to these to bring about the rhythms in the movements of fish. But it is found that neither the tides nor moonlight can fully explain the phenomena, for, considering moonlight, these things happen on nights when dense clouds obliterate completely the additional light of the full moon.

The East Anglian fishery continues during October and November, months when the cloud concentration is often considerable, and the Californian Smelt appears to be as accurate in its arrival in the coastal waters on cloudy nights as it is on clear nights.

The connection between moonlight and the swimming of organisms

on which the herring feeds must not be overlooked, however, but even such an explanation as this does not altogether help, for in the East Anglian area in autumn the herrings — with few exceptions — are not feeding. The rhythm in the Northumberland coast fishery, as observed in 1933, was one, it will be remembered, in which the peaks occurred during the week of "first quarter", a time when the moon's disc is only partly visible. In this case, we may have found a secondary cause of the fluctuation, for, since the herrings of the Northumberland summer fishery are all feeding, it should follow that a rhythm in the catches of fish might depend on a rhythm in the abundance of the organisms which they are eating. If not actual abundance, it may be that the copepods which form the main diet in this area are better developed at one period than another, and a change in their condition, so that they become more succulent, may be a great attraction to the fish. The possibility of such a cause is suggested after reading M a r s h a l l (5), who found that the copepod *Calanus finmarchicus* took more food by night than by day, and that even the presence of bright moonlight would interfere with the feeding of *Calanus*. The difference in the amount of food (diatoms etc.) taken in the day and night was not so great in summer as in winter, but the absence of moonlight at new moon might possibly be sufficient to cause a rhythm in the feeding of *Calanus*, and consequently one in its general condition as an article of diet for the herring. If this organism was "in season" — so far as the herring is concerned — at the period of new moon, is it not possible that the concentration of fish which would follow would affect the landings of herrings slightly later — in the week of "first quarter"? If this were so, then it would appear that the lunar influence on the North Shields herrings is of a somewhat indirect nature.

The other outstanding lunar effect is tides, but these, like moonlight, can have little to do with the production of the rhythm in the East Anglian landings, for if the monthly peaks are due to the influence of the full moon "spring tides", why is not a similar effect noticed at the new moon "springs"? It is true that the full moon springs in this area are slightly stronger than the new moon springs, but the difference should not be great enough to cause such a difference in the concentration of the fish as shown in Figure I, for example.

If the cause were purely tidal, we should expect a series of fortnightly maxima in the landings.

There is still another possibility concerning the cause of the fluctuations in the herring catches. We have seen that the Californian Smelt behaved in a peculiar manner at the time of spawning, as also did the Palolo worm, and it appears that the regular changes of behaviour in these animals are sexual ones of definite periodicity. The increase in weight of the gonads of the Red Sea sea-urchin at the time of full moon is another instance of sexual rhythm. Now, the East Anglian autumn herrings are all fish preparing to spawn in winter.

Their gonads are developed, some more than others, and it may be that some lunar rhythm has been impressed on the fish, causing them to behave in a peculiar manner at lunar intervals during the pre-spawning period; that is, like the cases mentioned above, the rhythm is a sexual one.

Our colleague, C. F. Hickling, who has been for some time studying the lunar periodicity of the hake catches, attempted to examine the change in weight of herring gonads throughout the season. (It was almost impossible in the case of hake, as it meant spending a long continuous period at sea if suitable data were to be collected). He discovered a rhythm in the change in weight of the herring gonads, but at the same time a similar rhythm in the change of length of the fish was found, so that it was not possible to explain the gonad change as a purely sexual one. This work, however, is continuing.

Graham (3), sailing from Lowestoft and Yarmouth in drifters, has made some interesting and important observations on the "swimming" of herrings during the autumn fishing.

The fish, he thinks, may behave in two ways. Either they swim quietly and languidly through the water, so that they are able to see the nets and negotiate them safely, or they behave like flocking birds, herding mammals or human beings in a riot, in which condition they dart about in masses and are thus unable to escape the nets. This state of excitement may, he suggests, be caused by panic, migratory impulsive or sexual urge, and it is quite possible that the first two of these are partly responsible for the irregular fluctuations in the catches and that the third, the sexual excitement, under the influence of the lunar rhythm, is the cause of the regular monthly "gluts". However sceptical we may feel, it cannot be denied that the connection between the moon's revolution round the earth and monthly rhythms in certain marine animals and even in human beings, appears to be outside the bounds of coincidence. In the case of the herring fluctuations, however, we are not able to find out if the period of change is $27\frac{1}{3}$ days — the time taken by the moon to make one complete revolution of the earth — or $29\frac{1}{2}$ days — the interval between two full moons, for the daily fluctuations make it impossible to point to definite days on which the rhythmic peaks occur, so we must be content to observe the changes by seven day periods, and designate the interval between the maxima as merely a "monthly" one.

The moon has always been a "mystery" satellite, and has often been blamed, in many cases quite wrongly, for purely accidental happenings on earth. One of its alleged associations with human beings is found in the word "lunacy" — a form of madness originally supposed to be intermittent and to be controlled by the moon's phases, and even in the present year one read, concerning an inquest on a lady who fell from her horse and sustained fatal injuries, that a juror asked whether the full moon could have the effect of making the deceased giddy and thus causing the fall. A witness replied that this was considered possible.

As Fox has shown so well, there is no limit to the number of lunar beliefs which can be discovered throughout both the civilised and uncivilised world, and we feel that by the publication of this paper we have added a morsel to the account he has already written. We have by no means explained the phenomenon of the fluctuation of the herring catch, because with our present knowledge it is impossible to do so. It may be explained some day by physicists, or it may for ever remain a closed book.

Fox opened his discussion with the quotation from Hamlet, *"There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy"*. We, at the close of ours, can best sum up the feelings of dissatisfied fishermen during a poor autumn fishery by quoting Hippolyta in "Midsummer-Night's Dream" — *"I am weary of this moon; would he would change"*.

Summary.

This paper has been written with two objects in view. One was to make a contribution to the general study of lunar periodicity in fishes, and the other was to increase our knowledge of the fluctuations of the East Anglian herrings, so that more accurate forecasts may be made.

We have found a definite rhythm in the quantities of herrings caught off East Anglia, a monthly rhythm with maxima coinciding with the period of full moon, but the preliminary observations on the fisheries of North Shields and Grimsby are not so conclusive. Regarding the abundance of herrings in the great autumn fishery, we learn that an early October full moon is not likely to cause a definite peak in the landings, and the best condition for a productive fishery appears to be when the October full moon occurs during the second week, for in this case it is found that the peak in the landings which accompanies this moon is approximately equal to the peak which appears at the time of the November full moon. Under these circumstances a period of about five weeks of good fishing can be expected.

The case of a late October full moon is interesting. When the full moon occurs in the last week, only one prominent peak appears in the fishery, so it follows that not only is the effective period of fishing very short, but also that a poor fishery would result in the event of serious gales during the week of full moon.

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Legend to Table I

on pages 238—239.

The dates in the table on pages 238—239 represent the mid-points of seven-day periods calculated from the dates of the October and November full moons. Above the date, in italics, is the percentage of the season's catch taken in each period, and below the date is the catch for each period in crans. The dates in heavy type are those on which the October and November full moons occurred.

1925. . . .	*1* Sept. 17th 7,754	21st	*2* Sept. 25th 11,859	*6* **Oct. 2nd** 45,404	*9* Oct. 9th 65,476	13th
1933. . . .	*1* Sept. 18th 3,731	22nd	*2* Sept. 26th 7,192	*1* **Oct. 3rd** 2,703	*4* Oct. 10th 17,142	14th
1922. . . .	*1* Sept. 20th 3,963	24th	*2* Sept. 28th 8,759	*7* **Oct. 5th** 29,311	*23* Oct. 12th 101,422	16th
1930. . . .	*2* Sept. 22nd 14,271	26th	*3* Sept. 30th 24,748	*6* **Oct. 7th** 49,562	*18* Oct. 14th 143,014	18th
1927. . . .	*1* Sept. 26th 8,214		*5* Oct. 3rd 33,778	*21* **Oct. 10th** 128,605	*16* Oct. 17th 98,473	21st
1924. . . .	*2* Sept. 27th 19,667	1st	*6* Oct. 5th 53,806	*21* **Oct. 12th** 194,449	*18* Oct. 19th 164,723	23rd
1932. . . .	*3* Sept. 29th 10,809	3rd	*3* Oct. 7th 12,200	*14* **Oct. 14th** 56,284	*14* Oct. 21st 55,325	25th
1921. . . .	*1* Oct. 1st 6,813	5th	*4* Oct. 9th 19,351	*20* **Oct. 16th** 95,881	*18* Oct. 23rd 89,178	27th
1929. . . .	*2* Oct. 3rd 13,289	7th	*6* Oct. 11th 47,087	*18* **Oct. 18th** 142,521	*11* Oct. 25th 88,732	29th
1926. . . .	*3* Oct. 6th 18,507	10th	*10* Oct. 14th 67,356	*37* **Oct. 21st** 240,555	*14* Oct. 28th 90,936	
1923. . . .	*11* Oct. 9th 57,192	13th	*24* Oct. 17th 129,489	*27* **Oct. 24th** 146,519	*17* Oct. 31st 91,274	4th
1931. . . .	*10* Oct. 11th 51,735	15th	*19* Oct. 19th 101,963	*35* **Oct. 26th** 185,052	*11* Nov. 2nd 61,081	6th
1928. . . .	*9* Oct. 13th 61,729	17th	*21* Oct. 21st 146,743	*33* **Oct. 28th** 225,555	*20* Nov. 4th 139,875	8th

I.

13 Oct. 17th 98,724		*17* Oct. 24th 125,840	*33* **Oct. 31st** 243,574	*12* Nov. 7th 90,055	11th	*7* Nov. 15th 48,634
19 Oct. 18th 74,743	22nd	*16* Oct. 26th 59,961	*16* **Nov. 2nd** 60,623	*33* Nov. 9th 127,022	13th	*8* Nov. 17th 32,252
12 Oct. 20th 55,034	24th	*20* Oct. 28th 90,022	*11* **Nov. 4th** 49,145	*18* Nov. 11th 79,663	15th	*6* Nov. 19th 25,384
20 Oct. 22nd 158,790	26th	*12* Oct. 30th 97,870	*21* **Nov. 6th** 172,303	*14* Nov. 13th 109,560	17th	*4* Nov. 21st 34,442
16 Oct. 25th 100,047	29th	*14* Nov. 2nd 87,773	*19* **Nov. 9th** 115,982	*7* Nov. 16th 41,686	20th	*1* Nov. 24th 7,146
15 Oct. 27th 141,976	31st	*14* Nov. 4th 129,616	*14* **Nov. 11th** 132,768	*7* Nov. 18th 63,174	22nd	*2* Nov. 26th 22,454
12 Oct. 29th 47,333	2nd	*21* Nov. 6th 84,932	*21* **Nov. 13th** 84,464	*10* Nov. 20th 38,793	24th	*3* Nov. 28th 12,335
13 Oct. 31st 64.395	4th	*10* Nov. 8th 47,217	*23* **Nov. 15th** 112,933	*7* Nov. 22nd 35,550	26th	*4* Nov. 30th 19,996
25 Nov. 2nd 201,802	6th	*12* Nov. 10th 98,232	*14* **Nov. 17th** 112,732	*8* Nov. 24th 60,929	28th	*5* Dec. 2nd 39,434
13 Nov. 4th 85,126	8th	*11* Nov. 12th 70,003	*6* **Nov. 19th** 38,942	*4* Nov. 26th 25,951	30th	*1* Dec. 4th 4,888
8 Nov. 8th 40,974	12th	*5* Nov. 16th 26,384	*6* **Nov. 23rd** 35.054	*2* Nov. 30th 10,954	4th	*0* Dec. 8th 2,504
8 Nov. 10th 43,891	14th	*4* Nov. 18th 21,909	*8* **Nov. 25th** 44,382	*2* Dec. 2nd 13,043	6th	*2* Dec. 10th 11,014
9 Nov. 12th 62,075	16th	*2* Nov. 20th 13,660	*2* **Nov. 27th** 11,071	*2* Dec. 4th 15,098	8th	*1* Dec. 12th 7,350

A Microprojection Machine Designed for the Study of Fish Scales.

By

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United States Bureau of Fisheries.

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A new microprojection machine designed by the authors for the study of fish scales has been tested and used since March, 1931, and found satisfactory by every member of the research staff of the Bureau of Fisheries engaged in fishery investigation on the Great Lakes, as well as by other scale investigators. The machine has been employed successfully also for various purposes other than scale reading, as, for example, photomicrography, drawing of microscopic objects, and class demonstrations. A description and blue print of this apparatus has been sent on request to several fishery investigators in this country and Canada. In the belief that other investigators may find the machine useful in their work, descriptive details are presented herewith.

In 1923 the senior author (Van Oosten 1923) described a simple microprojection apparatus that greatly facilitated the reading and measurement of fish scales. The method simply involved the direct projection of the scale image, through an ordinary microscope, upon ground glass. Although this method of studying scales was a vast improvement upon the known methods in vogue at that time, one principal criticism developed in its use: the investigator was unable to reach and change his slides from his working position behind the machine. To eliminate this inconvenience without sacrificing any of the good features of the older apparatus the machine described in this article was constructed.

The essential feature of the new device consists in changing the axis of projection from horizontal as employed in the older machine to vertical and, by interposing a reflector, projecting the image on a screen placed at a convenient working angle and at proper height. The

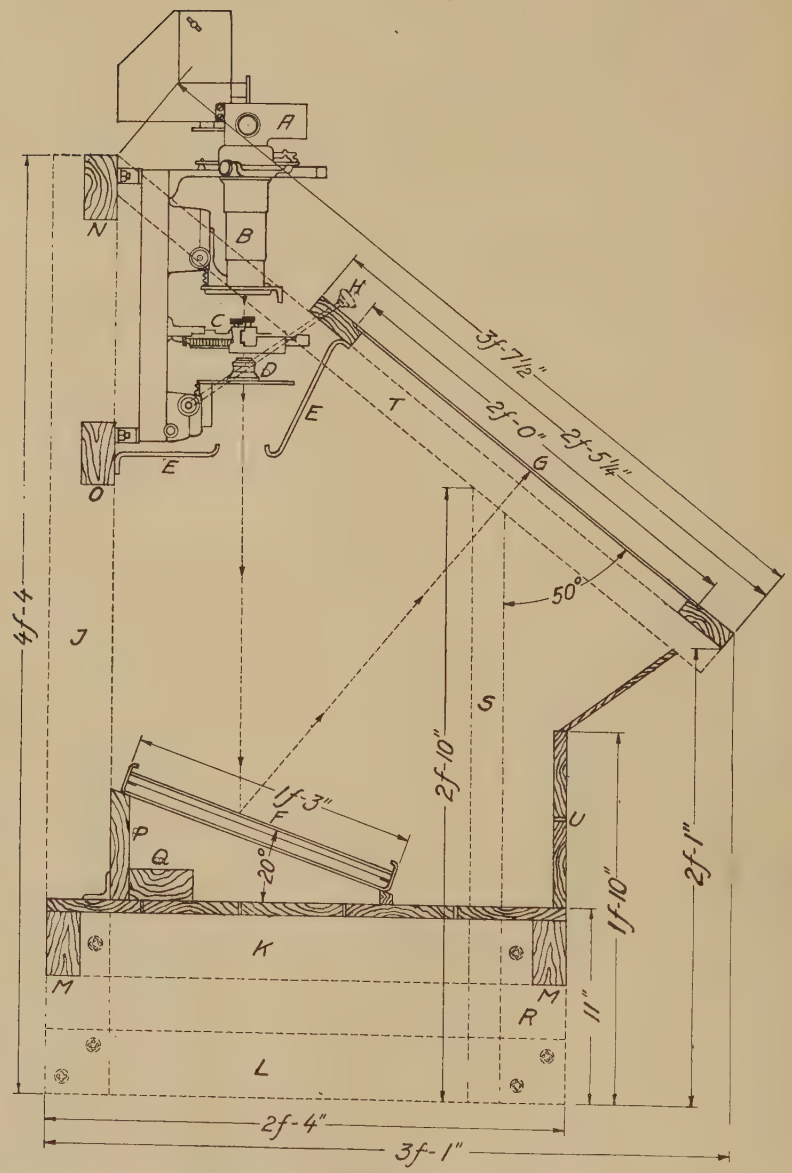

Figure 1. — Cross section view through center of microprojection machine. Scale is approximately 3/32 inch to 1 inch.

most obvious advantage of the apparatus here described is its ease of operation. The investigator, seated comfortably, is able to work without undue fatigue for long hours on the inclined desk-like surface of the projection screen, and the adjustment of illumination on the screen itself permits use of the machine in subdued daylight, thus making reading of the measuring scale and recording of data easy and free from eye strain. The cost of the machine is insignificant in the case of laboratories that already possess some type of microprojector or drawing apparatus with microtessar lenses. In the United States this cost, excluding labor and the front surface mirror, would be approximately $ 15.00.

Figure 1 represents a cross section view through the center of the machine. End structures are indicated by broken lines, while those structures that run through the center of the machine (on the plane of the drawing) are shown by solid lines. The plan, with the exception of the sketch of the microprojector, is drawn to the approximate scale of $^{3}/_{32}$ inch to 1 inch. Use should be made of the dimensions shown in the figure to avoid any inaccuracies that may have crept into the proportions of the drawing.

Optical Equipment.

The projection equipment employed consists of a Bausch and Lomb microprojector, No. 4354, which is fitted either with an arc light (Figure 1, A) or with an incandescent light (Figure 2). Both lights are interchangeable and fit into the collar of the condensing lens tube (B). The incandescent light, which is cheaper than the arc light in initial cost as well as in maintenance, serves admirably for all types of scales except those of the old fish of certain species, whose scales being very dense require the stronger illumination of the arc light.

The lens equipment most useful for scale study consists of 48 millimeter and 32 millimeter microtessar objectives that fit into the mounting, D. We have also a 72 millimeter microtessar which is useful only for extremely large scales and a 16 millimeter microtessar which is useful for extremely small scales. Magnifications obtained with the various objectives in our machine are approximately as follows: 72 millimeter objective, 17 diameters; 48 millimeter, 26 diameters; 32 millimeter, 43 diameters; and 16 millimeter, 81 diameters.

The use of achromatic objectives and projection oculars has been found unsatisfactory since these provide a much smaller field than do the microtessars. The ocular tube and the two substage condensers which are never used with microtessar objectives are removed from the microprojector to facilitate working operations.

Object Stage.

The original position of the object stage is changed. The stage (C) is inverted so that the slide, when in position, lies next to the substage condenser instead of next to the objective. Further, the stage is moved nearer to the objective and is attached to the opposite side (lower in

Figure 2. — Photograph of microprojection machine.

Figure 1) of its base to provide additional working space for the manipulation of slides in the mechanical stage.

Supporting Framework.

In the construction of the framework rigidity is of utmost importance to prevent errors of distortion in the magnified image due to the settling of the machine.

Two vertical uprights (J), each 4 feet 4 inches long, are constructed of 4 by 4 inch Grade A fir. These are held together by three cross-braces (N, O, and M), each 2 feet 4 inches long, made of 2 by 4 inch clear fir. The cross-braces are mortised into the uprights (J) and fastened with two $^3/_{16}$ inch carriage bolts in each joint. Two bolts are used in each joint to prevent side-play. Since the microprojector is bolted to the two cross-pieces, N and O, the placement of the latter must be gauged according to the length of the supporting base of the microprojector used.

The end braces (K and L), made of 2 by 4 inch clear fir, are mortised into the uprights (J) and also into the front posts (R), indicated by broken lines, and bolted. The lower braces (L) are each 2 feet 4 inches long but each upper brace (K) is only about 2 feet 1 inch long, since it is placed between and butted against the two cross-braces, M. The front posts (R), each 10 inches long, are constructed of 4 by 4 inch fir, and are braced in front by the cross-piece, M, which is made of 2 by 4 inch clear fir and is 2 feet 4 inches long.

A floor, the surface of which is 11 inches above the base line, is constructed on top of the two end pieces, K. Ordinary fir flooring is used. It is of utmost importance that this floor be absolutely level.

Projection Screen.

We find that for a study of scales the most satisfactory projection screen (G) is constructed as follows. Between two sheets of $^1/_8$ inch (double strength) window glass, 24 inches square, is inserted and uniformly stretched a sheet of light colored (not the dark) dental rubber dam, also 24 inches square[1]). The glass should be carefully selected to avoid bubbles, scratches, and other defects. The edges of the two sheets of glass are sealed with adhesive tape, and several coats of varnish are then applied to the tape (Figure 2). The rubber so sealed between the glass will last a relatively long time. Our rubber screen used continuously for nearly two years is just beginning to show slight evidence of deterioration. A temporary substitute for the rubber dam may be had by coating a piece of light yellow engineer's tracing velum with a light lubricating oil (such as "3 in 1") and sealing the velum between the two sheets of glass.

Although a single piece of ground glass did not give as good results as the rubber screen in projecting scales, it gave superior results in the

[1]) We are indebted to Mr. H. L. Shippy of the Bausch and Lomb Optical Company who suggested to us the use of the dental rubber dam for our projection screen.

projection of histological, cytological, and embryological sections for demonstration purposes. Flashed opal glass was found to be unsatisfactory in all cases since the image produced lacked definition. The machine can also be excellently adapted for purposes of drawing by removing the rubber screen and replacing it with a single piece of clear glass. The clear glass permits the use of fairly heavy drawing paper.

The framework for the projection screen should be constructed of birch or oak, as soft woods tend to sag with the weight of the glass. The rabbetting of the frame to hold the glass should be $^3/_8$ inch wide and deep enough so that the surface of the frame and glass will be flush. The frame is constructed of material 3 inches wide and $1^1/_8$ inches thick and when finished has inside dimensions of $23^1/_4$ inches square and outside dimensions of $29^1/_4$ inches square. The screen is held firmly in place by four metal plates, each about 2 inches long, which fit over the edge of the glass. The two plates at the bottom of the screen are screwed to the frame while the plates at the upper end of the screen along the sides are each fastened with a $^3/_{16}$ inch bolt fitted with a wing nut to facilitate removal of the screen.

The framework for the projection screen is held in place by two slanting braces (T) made of 2 by 3 inch clear fir, screwed to the face of the upper cross piece (N), and supported toward the front of the machine by two uprights (S), each 2 feet 10 inches long, made of 2 by 3 inch fir. The vertical supports (S) are adjusted so that the projection screen will set at an angle of 40 degrees with the horizontal or 50 degrees with the vertical as indicated on the drawing.

Mirror.

The use of a front surface mirror is highly desirable. Such a mirror (F), 15 inches square, is used by us. It is suggested, however, that an ordinary plate glass mirror of good quality which is free from flaws in the silvering might give satisfactory results at much less expense.

The mirror is placed at an angle of 20 degrees with the horizontal, that is, at one-half the angle of the projection screen (G) which was placed at an angle of 40 degrees with the horizontal. The mirror (F) is supported by the angular block, P, which is screwed to the block, Q, which is in turn securely fastened to the floor.

Final placement of the mirror should be made only after complete assurance, by tests with a stage micrometer, that magnification is everywhere uniform in the illuminated field on the projection screen — that no discoverable optical distortion exists.

Cabinet.

A shield (E) made of galvanized iron and fitted with an aperture and collar approximately 4 inches in diameter is fitted beneath the microprojector. The entire cabinet (Figure 2) is boxed in with composition board. The back of the cabinet, placed between the uprights (J), is fastened with small bolts fitted with wing nuts so

that it may be removed readily in order to clean the mirror. If a front surface mirror is used, a slot and sliding track for the mirror cover must be provided, preferably in the right side of the machine (Figure 2). The front partition (U) of the cabinet must not extend vertically more than 22 inches above the base line or it will intercept part of the reflected image as it passes from the mirror (F) to the projection screen (G).

A small drawer to hold lens paper, extra objectives, extra carbons, etc. may be constructed and fitted on a slide beneath the metal shield (E) and in the right side of the cabinet (Figure 2). This drawer should be short enough to avoid any interception of the beam of light as it passes through the aperture in the metal shield (E).

The rheostat for the arc light or the transformer for the incandescent light, or both, if the two types of illumination are to be used interchangeably, are housed in a compartment on the left of the microprojector above the metal shield (E). This compartment is lined with asbestos paper and fitted with two ventilation apertures, one on top and one in the side (Figure 2).

The exterior of the cabinet is stained and varnished, but the interior is painted a dull black in order to secure the best image intensity on the screen and to avoid reflection in case the apparatus is used for photomicrography.

Wiring.

An ordinary tumbler switch mounted in the top of the transformer or rheostat compartment controls the light. This switch should be inserted on the high voltage side of the rheostat or transformer. If both types of illumination are used, as is the case in our machine, a double system of wiring and switches is necessary. We found it desirable, for the sake of safety, to have only one cord carry the current supply into the machine. As a further measure of safety a cord fitted with the female half of a "come-apart" plug is used. This cord is attached to one of two short connections each fitted with the male half of a "come-apart" plug and connected directly to the switches in the machine.

Focusing Device.

Focusing is done by means of a high-ratio geared focusing device. The gears of an inexpensive hand drill are used intact. Into the chuck of the drill a 1/8 inch rod is fitted that extends through the upper right hand corner of the frame that holds the projection screen. A brass door knob (H) makes a very convenient operating handle (Figure 2). To the face of the larger gear of the hand drill a piece of strap iron is bolted, and through the center of this piece of iron a piece of 1/8 inch rod is fastened that extends to the coarse adjustment of the microscope unit where it may be attached by any one of several obvious methods. The gears are suspended and held in place by means of a piece of strap iron screwed to the cabinet frame.

Accessories.

The millimeter rule used for the measurement of projcted scales is permanently attached to the cabinet by means of three sections of an ordinary zigzag rule (Figure 2). This permits the use of the millimeter rule at any angle or position in measuring scales on the screen. It was also found very convenient, in case the arc light is used, to attach a small rear-view automobile mirror to the right side of the cabinet at such an angle so as to provide the investigator from his working position with a full view of the carbons in the arc lamp (Figure 2). In the photograph also note the position of the data sheet and of the shelf through which a hole has been cut of a size that holds the extra lamp.

Adaption for Photography.

To adapt the machine for photographic purposes a piece of ¼ inch veneer, 24 inches square, braced to prevent warping, is substituted for the glass projection screen. A hole is cut through the center of this piece of veneer to accommodate an ordinary photographic plate-holder with a ground glass back. The image is focused on this back prior to insertion and exposure of the plate. Exposure is made either by turning the light on and off, or by employing a large camera shutter fitted over the aperture of the metal shield (E). If a shutter is used the interior of the cabinet below the metal shield (E) must be light-tight. If the intensity of the light is too great for successful photography, it can be reduced by means of a smoked glass filter which is inserted in the mounting of the heat filter that lies immediately below the condensing lens tube (B). We found that the arc light used in conjunction with a darkly smoked filter yields the most satisfactory photographs.

Literature Cited.

1923. Van Oosten, John. A Study of the Scales of Whitefishes of Known Ages. Zoologica, II, 17, pp. 380—412. New York Zoological Society, New York.

Letter to the Editor.

IN Journal du Conseil, Vol. IX. No. 1 (1934) reviews have been given by H. J. B.-W. of the various papers in Hvalrådets Skr. No. 7. In addition to accounts of the papers some critical remarks appear, and as regards "A mathematical method for the study of growth" and "The optimum catch" the criticism is of such a nature that it necessitates some reply. As far as I understand the reason for the critique of our methods, I think it is due to the fact that H. J. B.-W. represents another opinion as to the employment of statistical methods in biological investigations from that held by the authors of the papers mentioned. To make my ideas clearer, I will in the following confine myself to the consideration of an example.

Suppose that there is given a frequency series — for instance a series resulting from length measurements of fish —:

x :	x_0	x_1	x_2	.....	x_n
$H(x)$:	$H(x_0)$	$H(x_1)$	$H(x_2)$	.....	$H(x_n)$

in which x denotes the values of the quantitative sign (lengrh of the fish) and $H(x)$ the number of individuals with this value. Very often the investigator must try to characterise this series by some few figures, as it is in itself unsurveyable. As a rule the arithmetical mean is calculated:

$$m \qquad \frac{\Sigma x \cdot H(x)}{\Sigma H(x)}$$

The significance of this quantity is easily understood by everybody, without any deeper insight into mathematical statistics. In the science of statistics, however, the mean is taken as a preliminary summary expression of the series as a whole, and besides some other quantities are used for characterising the series. As a rule some other symmetrical functions of the observations are used (moments, seminvariants, factorial sums etc.). The main point to which I should like to call attention is that in mathematical statistics the arithmetical mean is but one of

the many quantities which are used for the purpose of characterising the frequency series, although it is the most important one.

From both a statistical and a biological standpoint one must reject the opinion advanced by H. J. Buchanan-Wollaston that the shape of the frequency series (or curve) is a function of the value of the mean. He says: "The shape is merely a function of the position of the mean." (Journal du Conseil, Vol. VIII, No. 1, p. 9, 1933). It is obvious that the value of the mean depends on the shape of the frequency series (or curve) and its position on the value-scale of the quantitative sign.

In many cases the arithmetical mean forms a sufficient basis for the elucidation and solution of the problems in question. In other cases, however, it is not sufficient, and a more complete characterisation of the series is necessary. As mentioned above we can calculate some other symmetrical functions — for instance the seminvariants — for this purpose. But here the theoretical frequency functions also come into use. If, for instance, the series has an appearance of approximating to the exponential frequency function:

$$f(x) = \frac{1}{\sqrt{2\pi} \cdot \sigma} \cdot e^{-\frac{(x-m)^2}{2\sigma^2}}$$

it is completely characterised by only two figures m and σ, the mean and the standard deviation respectively.

The theory of frequency functions is one of the most fundamental and difficult objects of the mathematical statistics. Professor Karl Pearson's system of frequency functions (or curves) is well known (see for instance: W. Palin Elderton: Frequency-Curves and Correlation, London 1906). Some mathematicians keep aloof from Prof. Pearson's treatment of these statistical phenomena (see for instance Prof. J. F. Steffensen: Matematisk Iagttagelseslære, Kjøbenhavn 1923). They argue that only those functions which are founded on the theory of observations can be considered as frequency functions. Some other researchers have, however, advanced farther on the way of Prof. Pearson. Their task is to find methods by means of which the "best-fitting curve" to fit to statistical data can be obtained. If we consider the mathematical functions found in this way as formulae of interpolation, nothing can be argued against the methods. But I do not understand the purpose for biological investigations of finding such algebraical functions as they cannot, of course, give any deeper insight into the problems than the empirical series itself or its graphical interpretation. Evidently, no logical or causal connection exists between the empirical series and the formula of interpolation. The modern methods of finding the "best-fitting curve" to fit to statistical data have some interest for mathematical algebra, but no importance for the biological investigations.

It is a matter of fact that in very few cases can it be understood why a frequency series can be approximately substituted by a certain

function, and the frequency function must therefore be considered as a formula of interpolation. This fact thus applies to the agreement which very frequently appears between the exponential function and the statistical series obtained as results of measurements, enumerations of organs etc. The question arises, therefore, whether the agreement with the exponential function is of greater importance than the agreement with any other algebraical function. It is of no interest to discuss this question in a theoretical way. Experience, however, cannot be neglected. It shows that the agreement with the exponential function very frequently appears if the original material is analysed to a certain extent. On the other hand it is not to be expected that agreement with the exponential law appears without such sub-division because the original material is as a rule composed in a very complicated way of various groups. According to experience, however, the fact that a statistical series resulting from length measurements, enumerations of organs etc. does not agree with the exponential function, raises the question whether sub-division may result in frequency series which agree well with the exponential function. As such a means for statistical analysis I think the exponential frequency function (in other cases other frequency functions) has its main importance.

The exponential function is symmetrical. Consequently skew frequency series do not agree with this law. But skewness is just one of the characters which most strongly invites to sub-division of the material. The reason why I made some remarks on skewness in my paper is the necessity of emphasizing that, when a skew frequency series appears, sub-division will as a rule result in symmetrical series with different means. This is a fact of experience and has no bearing upon dogmatical speculations.

As regards the remarks of H. J. B.-W. on Prof. G u l d b e r g's approximation coefficient, I will confine myself to saying that the decision whether the empirical series appears to approximate to the binomial frequency function or not, is, of course, left to personal judgment. The approximation coefficients are the mathematical criteria of the correctness of our hypothesis. The very same applies as well to the method of Prof. P e a r s o n. I cannot understand that the decision by approximation coefficients is a matter of difficulty. In some cases the coefficients vary between the limits of 0.7 and 1.5, in other cases they take the values from 0 to 5, 6 or 7. Moreover, it must be mentioned that the approximation coefficients ought not to be used alone. Both Prof. G u l d b e r g and I have, in addition, investigated whether calculated and empirical frequency numbers agree with each other.

If we go into statistical philosophy, which seems to be of great interest of "modern statisticians", I think that the philosophical foundation of the exponential frequency function is as well cleared up as can be expected. It is proved that a quantity (A) which is the sum of a number of elementary quantities:

$$A = \frac{a_1}{n} + \frac{a_2}{n} + \frac{a_3}{n} + \ldots\ldots\ldots + \frac{a_k}{n}$$

takes the form of the exponential frequency function if the number of terms of this sum is sufficiently great.[1]) If we imagine that each of these terms represents an elementary cause which within a group of individuals varies relatively unessentially, it will be understood that these individuals are distributed in accordance with the exponential function on the values of the quantitative sign A. Or in general, if the observed quantity can be taken as a sum of terms, the frequency distribution tends to take the form of the exponential frequency function even if the single terms do not follow this law. All biological quantities may be taken as such a sum or at any rate as due to a large number of elementary causes. "Thus the deviation of the actual chest measure of an individual from the average may be regarded as the sum of a very great number of very small deviations (positive or negative) due to the separate factors in the heredity and environment of the individual." (Whittaker and Robinson, p. 167).[2]) This philosophical hypothesis gives, in my opinion, an excellent explanation of the frequent occurrence of exponential series in the biological investigations.

If we now consider the mathematical methods for the treatment of the sigmoid growth, the very same discussion as above can be applied. Of course, not so extensive experiences are available as in the case of frequency distributions resulting from length measurements, enumerations of organs etc. As shown in my paper, however, growth can be studied in the same way as frequency series, i. e. as frequency distributions according to birth- (or death-) number. This is the general part of the method. The examples examined in my paper, appeared to be in good accordance with the exponential frequency function. Whether the agreement with this law is a general rule or not, only experience can prove. A theoretical discussion of this fact is of no value. The examples examined by me, were taken from essentially different types of organisms (yeast cells, herring, students), and there are thus good reasons for the belief that the exponential function in the treatment of the sigmoid growth should very frequently come into question. With regard to skewness or symmetry of growth, a theoretical discussion cannot, of course, lead to profitable conclusions. But to my thinking it must be considered as very remarkable if all the samples examined by me represent the exceptional case and not the rule. Moreover, experience shows in this case that skewness can be due to inhomogeneity. Future experience only can give a correct answer to these questions.

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[1]) See about this matter:
[1]) M. W. Croftons: On the Proof of the Law of Errors of Observations, Lond. Trans. 159 (1869).
[2]) F. Y. Edgeworth: Law of Error, Cambridge, Phil. Trans. XX, 1904.

[2]) E. T. Whittaker and G. Robinson: The Calculus of Observations, London 1924.

When we are considering the growth-studies also, we are confronted with the very same dogmatical speculations which are so characteristic of the "modern statisticians". The fact that agreement with a certain mathematical function appears, has been taken as a proof of causal connection, and the sigmoid growth has been considered as a phenomenon homologous with certain autocatalytic chemical processes.

The method used for calculating the stock of whales (in "The optimum catch"), is of course subject to many errors. But this method possesses the advantage over other methods that the size of the stock and the fluctuations in it from year to year becomes not only known but understood as the result of known factors. I do not understand the purpose for biological investigations of substituting the curve of catches by the algebraical function $y = e^{a+bx+cx^2+\cdots}$ (which always appear in "modern statistical speculations") the coefficients of which mean nothing and cannot be understood.

Finally, I should like to add only that it must be remembered that we are dealing with biological problems, and that mathematical statistics in this connection are but a means towards the description and analysis of the empirical material. In his book "The Emperor's New Clothes" Prof. Johan Hjort writes: "When biology applies the statistical method, it starts from observations in Nature; it first obtains the necessary figures for the mathematical treatment of its subject by measuring or counting the things it is studying, and then draws its conclusions as to the variations within the material thus obtained. The next step is to look for factors which might influence the observed variations. It is in the cases when no such factors can be found that we hear the familiar statement that "chance" is the only explanation of the variation. But this is obviously to substitute the mind's own instrument for reality, and such statements are quickly forgotten as soon as the influence of factors in the environment is proved, as has been happening more than once in the ten or fifteen years."

Per Ottestad.

Reviews.

A. Schumacher. "Ozeanographie". Handwörterbuch der Naturwiss. II. Aufl., VII. Bd. Gustav Fischer, Jena, 1932.

To compress a treatise on oceanography into thirty pages of an encyclopaedia or dictionary without confining it to the broadest principles is an impossibility. Accordingly the article reviewed here has no detailed descriptions and no proofs of the few mathematical results which are given, but within its limits it is a useful work of reference.

The author begins with a section on the areas and depths of the oceans and then goes on to the chemical and physical properties of sea-water. Tables of the composition of "sea-salt" by different authors are given, and the opinion is expressed that no significant local variations are shown. The distribution of salinity is discussed with the aid of Schott's surface chart. In the reviewer's opinion it would have been preferable to retain the well-known σ_0 and σ_t everywhere, and it is hardly correct to give an equation in which S does not occur as expressing the relation between salinity and density. Paragraphs and tables are given to compressibility, the velocity of sound, the freezing and boiling points, the refractive index and other properties. It might have been worth while pointing out that the specific heat changes considerably under pressure and so affects the velocity of sound.

The gain and loss of heat by the sea, the distribution of temperature and its seasonal changes, the relative amounts of precipitation and evaporation and the formation of ice are treated at some length. It was doubtless want of space which prevented the inclusion of a chart of surface temperatures.

Under the head of oceanic circulation the author gives a short account of the surface currents and lays emphasis on the convergences; here, too, a chart would have been helpful. The deep circulation is illustrated by three meridional salinity sections and one of oxygen. A sketch of Ekman's theorem of the pure drift-current is given as far as is possible without mathematics, and also of Bjerknes' circulation theorem and its application to ocean currents, but no attempt is made to explain the method of computation. Two striking diagrams by Wüst illustrate the close agreement between observation and theory which may be attained in the case of the latter. The law of parallel solenoidal fields discovered by Ekman and Helland-Hansen is also given.

There is a section on surface and internal waves, and a series of wave forms determined by stereophotographs show that though the trochoidal theory is well supported by the mean of a large number of observations it is seldom so supported by an individual wave. The article closes with a short section on tidal streams and a list of some of the more important papers and books on oceanography.

D. J. M.

F. Spiess. "Das Forschungsschiff und seine Reise". Wiss. Ergebn. deutsch. Atlant. Exped. a. d. Forsch.- u. Vermessungsschiff "Meteor", 1925—1927. Bd. I. Berlin 1931.

A remarkable circumstance connected with the German "Meteor" expedition in the South Atlantic Ocean was that it should have been possible to carry it out at a time of such great financial difficulties, and indeed it would not have been possible were it not that the German Admiralty saw in it an opportunity of keeping in touch with their countrymen beyond the seas and that the *Notgemeinschaft* came forward with an offer of a contribution to the cost of the equipment. The programme was due to Dr. Alfred Merz and his deep interest in the problem of the general oceanic circulation. With his pupil Dr. Wüst he had studied all earlier observations bearing on the subject from the "Challenger" and "Gazelle" onwards and came to the conclusion that the small differences in temperature and salinity which had been smoothed out as due to instrumental errors had a real meaning, and that the meridional circulation was much more complicated than had been supposed, in fact fourfold. This theory was confirmed to a remarkable degree. The volume under review is the first of a series of scientific reports which are appearing at short intervals, and all which have appeared carry out Dr. Merz's wish that everything should be set down which could be of use or interest to those who in the future might have to plan another expedition.

The book begins with the history of the inception of the expedition, the original project of an expedition in the Pacific Ocean, which had to be abandoned because the radius of action of the "Meteor" was not large enough, the selection of the scientific and naval staffs, the equipment and the route, with the closely connected question of coal consumption. Later sections describe the ship and the special construction necessary for the work, such as the laboratory and the deep-sea anchor gear, the trial trip and the preliminary cruise to the Canaries to try out all the gear under working conditions. This latter disclosed many defects which had to be rectified if the expedition was to be in any way a success; not the least was the large coal consumption, which was met partly by alterations in the engine room and partly by an increased sail area.

The "Meteor" sailed on 16 April 1925 and returned on 2 June 1927, so that the voyage had lasted more than 25 months, during which time 310 stations had been worked and she had steamed more than 67,000 miles. The larger part of the volume is given up to a description of the voyage and cannot be noticed in detail. It is well illustrated and very complete and much of it will be familiar to those who have read Captain Spiess' earlier and more popular account, *Die Meteor Fahrt*. Other sections deal with navigation and magnetic observations made on land or are reports by the engineer and medical officers.

Dr. Merz did not live to see the success of the expedition which he had planned. He was taken ill at sea and had to be landed to hospital at Buenos Aires, where he died. But the programme had been drawn up with such care that when Captain Spiess took over the scientific leadership it could be carried on practically unchanged.

D. J. M.

H. U. Sverdrup and F. M. Soule. "Scientific Results of the 'Nautilus' Expedition 1931, under the command of Capt. Sir Hubert Wilkins". Parts I to III. Papers in Phys. Oceanogr. and Meteor., published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. Vol. II, No. 1. Cambridge, Mass., 1933.

In dieser ersten wissenschaftlichen Veröffentlichung über die "Nautilus"-Fahrt, die im Sommer 1931 die allgemeine Aufmerksamkeit auf sich zog, berichtet H. U. Sverdrup, der wissenschaftliche Leiter, über den Reiseverlauf und die ozeanographischen Arbeiten und deren Ergebnisse, F. M. Soule, dem die erdmagnetischen Arbeiten und die Echolotungen oblagen, über die Ergebnisse der Echolotungen. Die Schweremessungen, die durch den dritten beteiligten Wissenschaftler, B. Villinger, ausgeführt wurden, sind noch nicht veröffentlicht. — Das ursprüngliche Programm der Expedition sah bekanntlich eine Durchquerung des Nordpolarbeckens von Spitzbergen nach der Beringstrasse vor. Hierauf, wie auch auf einen Vorstoss bis zum Nordpol, musste man verzichten, da sich die Überfahrt des "Nautilus" von Amerika nach Norwegen und weiter nach Spitzbergen erheblich verzögert hatte. Leider konnte schliesslich aber auch die nunmehr von Sverdrup ins Auge gefasste ozeanographische Aufnahme des Meeres zwischen Nordwestgrönland und Spitzbergen *vom U-boot* aus nicht mehr durchgeführt werden, da kurz nach Verlassen der Adventbucht auf Spitzbergen das Tiefensteuer verloren ging. Trotz dieser schweren Havarie, die das Boot sehr leicht in verhängnisvolle Lagen hätte bringen können, entschloss sich Wilkins zu einer dreiwöchigen Kreuzfahrt am Rande des Packeises nördlich von Spitzbergen (zwischen 82° N. Br. 25° O. Lg. und 1° W. Lg.), um, soweit noch möglich, Erfahrungen über die Möglichkeiten wissenschaftlicher Arbeit an Bord des — allerdings nicht mehr tauchfähigen — Bootes zu sammeln, insbesondere über die Verwendbarkeit der Tauchkammer für die Ausführung der Tiefseebeobachtungen. (Die Tauchkammer wurde während der Beobachtungen unter Überdruck gesetzt, um an ihrem Boden eine Luke öffnen zu können, zum Wegfieren der Wasserschöpfer und Thermometer.) Es gelang, neun ozeanographische Stationen durchzuführen, wenn auch nicht immer in vollständigen Serien durch alle Tiefen, bei denen Temperatur, Salzgehalt, Wasserstoffionenkonzentration, Sauerstoff-, Phosphat- und Nitritgehalt bestimmt wurden (14 Beobachtungstiefen liegen zwischen 1000 und 3000 m.).

Die ausführliche Diskussion der Beobachtungen nach der technischen Seite hin führt zu dem Ergebnis — welches man bei dem höchst beschwerlichen Arbeiten in der Tauchkammer wie im engen gemeinsamen Wohn-, Arbeits- und Schlafraum ganz gewiss nicht ohne weiteres erwarten wird — dass die Genauigkeit der Bestimmungen praktisch derjenigen an Bord eines normalen modernen Expeditionsschiffes entspricht. Nur die Sauerstoffprobenentnahmen scheinen an einzelnen Stationen durch den Überdruck in der Tauchkammer beeinträchtigt zu sein. In den Kippthermometerablesungen konnte — ein praktisch belangloser — Einfluss der Körperwärme des Ablesers festgestellt werden; für die Erreichung der höchsten möglichen Genauigkeit ist also Ablesung im Wasserbad notwendig.

Zur Charakterisierung der angetroffenen Verhältnisse seien die Ergebnisse auf der nördlichsten "Nautilus"-Station, Nr. 2, vom 28. 8. 1931, 82° N. Br. 17.5° O. L., Tiefe 2655 m., wiedergegeben.

Tiefe	t°	S‰	O_2 ml./l.	O_2 %	pH	P_2O_5 mg./m³.	NO'_2N mg./m³.
5	— 1.23	—	—	—	—	—	—
50	0.40	34.36	7.17	90	8.14	47	1.0
100	(2.15)	.76	6.76	89	.06	57	
195	(2.70)	.97	6.64	89	.10	57	
295	2.63	35.00	6.90	93	.11	71	
395	2.55	.02	6.82	91	.11	71	
490	2.23	.01	6.91	92	.07	49	
590	1.82	.00	6.83	89	.02	67	0.0
784	0.75	34.92	6.84	88	.04	43	
1142	— 0.47	.92	—	—	7.94	72	
1330	— 0.65	.92	6.42	79	8.05	67	
1620	— 0.82	.93	6.52	80	.10	69	
2110	— 0.91	.93	6.58	80	.05	69	
2616	— 0.85	.93	6.41	79	.09	65	

Für die regionale Diskussion konnte Verf. die Beobachtungen vom "Nautilus" durch solche von Mosby ("Quest", August 1931) und von Devik ("Ringsael", 1922) ergänzen.

Das *arktische Wasser* der oberflächennahen Schichten wurde sehr wenig einheitlich in Temperatur und Salzgehalt befunden. Das darunter lagernde *atlantische Wasser* (in der Kernschicht mit einer Temperatur von 2 bis 3° und darüber und einem Salzgehalt von 34.99 bis 35.08 ‰, gegen das arktische und das Tiefenwasser abgegrenzt durch einen Salzgehalt von 34.9 ‰ bei einer niedrigsten Temperatur von 1°) reicht bis etwa 650 oder 750 m. hinab. Sverdrup betont die verhältnismässig grosse Veränderlichkeit des Salzgehaltes von Jahr zu Jahr, im Gegensatz zu früheren Auffassungen (bis 0.20 ‰). Die Berechnung der Strömung aus den hydrographischen Daten ergab für das atlantische Wasser nördlich von Spitzbergen Bewegung nach Ostnordost, also dem Schelfrande folgend, mit reichlich 10 cm./Sek. in 300 m. und etwa 7 cm./Sek. in 600 m. Tiefe. Dies entspricht den Vorstellungen von Nansen; Sverdrup ergänzt sie dahin, dass er von der linken Flanke dieser Strömung ein langsames Abkurven nach Nordwesten erfolgen lässt, mit Geschwindigkeiten zwischen 1 und 4 cm./Sek.

Im *Tiefenwasser* stellt Sverdrup in seinem Material neben der Temperaturzunahme auch eine Zunahme des Salzgehaltes gegen den Boden hin fest. Infolgedessen kann trotz des leicht überadiabatischen Temperaturgradienten noch gerade stabiles oder höchstens indifferentes Gleichgewicht herrschen. Hieraus folgert Verf., dass das unterste Bodenwasser aus einer Schicht stammt, in der Temperatur und Salzgehalt um ein Geringes höher sind als in dem Herkunftsbereich des übrigen Tiefenwassers. Eine Stütze für diese Annahme sieht er in dem hohen Sauerstoffgehalt des Bodenwassers, der an der tiefsten Station (Nr. 3) anscheinend zum Boden hin etwas zunimmt. Durch Vergleich der "Belgica"-Station im nördlichen Europäischen Nordmeer mit den "Nautilus"-Stationen sieht Sverdrup die Vermutung Nansens bestätigt, dass das Tiefen- und Bodenwasser des Polarbeckens aus dem Europäischen Nordmeer stammt, und dass zwischen Grönland und Spitzbergen eine Tiefe von mehr als 1000 bis 1500 m. vorhanden sein muss, durch die dieses Wasser nach Norden gelangt. Die spärlichen Daten aus grösseren Tiefen "widersprechen nicht der Auffassung, dass das Tiefenwasser in dem westlichsten Teil des in Rede stehenden Bereiches in das Polarbecken eindringt, dem Schelf (soll wohl heissen dem Kontinentalabhang) nach Osten folgt und sich nordwärts ausbreitet".

Der beschränkte Raum verbietet das Eingehen auf die weiteren Untersuchungen Sverdrups, z. B. über die Austauschgrösse, und auf die chemischen Befunde.

Die *Echolotungen* (etwa 300 Messungen) gestatten eine prägnantere Reliefierung des Schelfs und des Kontinentalabfalls nördlich von Spitzbergen. Nördlich von Nordostland reichen die geringen Tiefen weiter nordwärts als früher angenommen wurde; desgleichen ergaben sich in 82° N. Br. und 11 bis 14° O. Lg. Tiefen von nur 1200 bis 1500 m. anstelle der bisher vermuteten 2500 bis 3000 m. Der Spitzbergen-Grönland-Rücken konnte im östlichen Teil genauer profiliert werden, wobei dicht südlich desselben mit vier Einzellotungen eine begrenzte Tiefe von mehr als 3000 m. gefunden wurde, die vierte und kleinste bis jetzt bekannte derartig tiefe Einsenkung des Europäischen Nordmeers. Auf dem Rücken wurde zwischen 650 und 700 m. gelotet; die vermutete Satteltiefe von annähernd 1500 m. muss nach wie vor weiter im Westen gesucht werden.

Im Reisebericht betont der Verfasser mit grossem Nachdruck, dass nach dem Verlust des Tiefensteuers die Fortsetzung der Fahrt und damit die Möglichkeit, geophysikalische Beobachtungen zu machen, einzig der unbeugsamen Energie von Sir Hubert Wilkins zu danken gewesen sei. Das kann den hohen Respekt vor der Leistung der Wissenschaftler auf dieser dreiwöchigen Fahrt in keiner Weise schmälern. Unter denkbar schwierigen Arbeitsbedingungen gesammelt, ist das ozeanographische Material jetzt in dem vorliegenden Heft einer weitgreifenden Diskussion unterworfen worden.

Anmerkung bei der Korrektur: Die Bearbeitung der Schweremessungen von B. Villinger ist inzwischen in der gleichen Schriftenreihe erschienen. Hingewiesen sei auf eine Richtigstellung von V. W. Ekman zu einer vermeintlichen Bestätigung des Satzes von den parallelen Feldern, die Sverdrup in seinem "Nautilus"-Material gefunden zu haben glaubte (vgl. V. W. Ekman in Gerlands Beiträgen 1933).

A. Schumacher.

P. M. van Riel. "Surface temperature in the north-western part of the Atlantic Ocean". Konin. Nederlandsch Meteor. Inst. No. 102. Meded. en Verhandl. 35. 's Gravenhage, 1933.

This report is primarily an amplification of the Dutch Metorological Office's recent atlas of the Atlantic Ocean. It covers in greater detail the important deep-sea area between latitudes 37° and 50° N. and west of longitude 40° W., including the region of the Grand Banks and the Coastal shelf from St. John's to New York. The author has prepared tables and charts giving the monthly mean temperature at the surface for each one degree square. Current charts are presented showing the mean monthly current for each two degree square in the same region. These charts and tables are the outcome of averaging about 26,000 current observations and several times as many surface temperature readings recorded on board commercial steamers during the last 50 years.

The discussion (18 pages of text and 7 figures) includes an examination of the annual range of surface temperature, the mean temperature for the year, and the deviations from the mean, as well as the frequency of such deviations, in several characteristic small areas. The twelve current charts enable the author to examine the monthly changes of the line of convergence between the waters of arctic and tropical origin. As might be expected, this convergence zone is found to shift northward in summer and southward in winter.

The charts and tables have been carefully prepared and the English translation from the original Dutch is perfectly adequate. In short, this paper is by far the most complete summary that has thus far been published of the mean monthly conditions as reported by commercial ships.

The Newfoundland Banks and adjacent seas are an important region from the point of view of governmental aid to shipping, and students of ocean circulation will also welcome this study. It must be remarked, however, that division of the area, even into one degree squares, partly conceals the sharp thermal changes which are known to exist along the edge of the continental shelf and again at the northern border of the Gulf Stream. In the same way, the averaged observations do not show that the surface temperature is higher in the swift part of the current than on either side of it. Such higher temperatures are always found in the heart of the Gulf Stream whenever it has a northern component.

Reports of currents made by commercial vessels must always be used with caution, for it is only after a steamer has progressed a considerable distance that the current can be calculated, whereas the swifter currents are undoubtedly narrow. Moreover, the distance between dead reckoning and observed positions will give the sum of the wind controlled surface movements plus the more permanent deeper currents. Thus, when the short-period superficial movements are relatively great, as is usually the case over the continental shelf, the reports by passing ships fail to show the dominant drift of the underlying waters. For these reasons, the fact remains that no matter how carefully average surface conditions are presented, they cannot, beyond a certain point, further our understanding of the problem of ocean circulation. Only through subsurface observations can the true circulatory picture be revealed.

C. I.

S. E. Stenij. "Zur Theorie der Wasserschwingungen in einem begrenzten Meeresbecken mit besonderer Berücksichtigung des Einflusses vom Luftdruck." Soc. Sci. Fennica, Comm. Phys.-Math. VI, 16. Helsingfors, 1932.

Man hat früher versucht, das Verhalten des Wasserspiegels gegenüber Änderungen des Luftdrucks als eine Barometerwirkung aufzufassen, aber namentlich Witting hat gezeigt, dass nur beim Vergleich von Mittelwerten des Luftdrucks und des Wasserstandes eine einfache proportionale Beziehung herauskommt, während in den Einzelbeobachtungen des Wasserstandes der Einfluss der Schwingungen überwiegt. Das Verständnis der Schwankungen des Wasserstandes im Einzelnen erfordert daher die Untersuchung der freien und erzwungenen Schwingungen eines Beckens. Diese sind es daher, die der Verf. im ersten Teile seiner Arbeit behandelt, und zwar für den Fall eines beliebig begrenzten Beckens mit oder ohne Mündung, und mit senkrechten oder schrägen Wänden, aber ohne Berücksichtigung der Erdumdrehung. Die Behandlung der Aufgabe geschieht demnach von einem allgemeinen Standpunkte aus, und der Verf. findet den Weg hierzu in der Theorie der Integralgleichungen, wie dies Poincaré früher für die Theorie der Gezeiten getan hat.

Der zweite Teil beschränkt sich auf die longitudinalen Schwingungen in einem schmalen Meeresbecken, zieht dafür aber auch die Reibung mit in Betracht. Nach einer kurzen Charakterisierung der bisherigen Methoden zur Ermittlung der Eigenschwingungen von Chrystal, Proudman, Lord Raleigh, Sterneck und Defant schlägt der Verf. sodann einen neuen Weg ein, indem er ohne die Eigenschwingungen zu bestimmen,

von den Methoden Gebrauch macht, die d'Alembert bei der Behandlung der schwingenden Saite anwandte, und die auf eine Betrachtung *fortschreitender* Wellen und ihrer Reflexionen unter Benutzung der Charakteristiken der zu Grunde liegenden hyperbolischen Differentialgleichung hinauslaufen. Bei regelmässiger Form des Beckens lassen sich die Vorgänge durch Integrale bündig darstellen, während bei unregelmässiger Form eine Approximation durch Reihen nötig ist.

Sicherlich liegt an und für sich etwas gekünsteltes darin, etwa eine unregelmässige Verbiegung des Wasserspiegels in eine Summe von Eigenschwingungen aufzulösen, und der Gedanke des Verfassers ist um so natürlicher, die Wirkung eines fortschreitenden Luftdruckgebildes durch fortschreitende Wellen darzustellen. In welchem Grade er den Vorzug verdient, muss die praktische Rechnung ergeben, und man wird deshalb mit Interesse einer Anwendung der Stenijschen Theorie entgegensehen dürfen.

H. Thorade.

H. Thorade. "Methoden zum Studium der Meeresströmungen". Handb. biol. Arbeitsmeth. (Abderhalden) Abt. II, Teil 3, S. 2865—3095. Berlin und Wien 1933.

Dr. Thorade's review of the methods for studying the ocean currents is divided into nine chapters. Chapter I considers general questions concerning observations of currents and gives a survey of the possible methods, their advantages and disadvantages.

Chapter II deals with the drift methods. Thorade describes the results which can be obtained by the use of drift bottles or other drifting bodies, treats critically the deductions as to surface currents from dead reckoning and observed positions, and touches upon the indications as to currents which are given by the distribution of temperature, salinity or other characteristics of sea water. Thorade especially emphasizes the caution which must be exercised when drawing conclusions as to currents from tongue-like distributions of oceanographic elements.

Chapters III and IV are devoted to a survey of all known instruments for current measurements, including some regarding which details have not yet been published. Thorade describes each instrument so fully that the reader obtains a clear idea of the special features of each type, and can form his own opinion as to the most suitable instrument for his special purposes.

Chapters V, VI and VII deal with the critical treatment of the observations, their decomposition (e. g. in tidal currents and rest currents) their combination and representation in charts.

The two last chapters, VIII and IX, deal with the importance of the wind and density distribution in connection with the ocean currents. The Ekman spiral is discussed and the computation of currents from the observed densities is given. These chapters are more condensed than the preceding, but they contain a clear and concise treatment of the fundamental principles of dynamic oceanography and throw light on all essential questions. Finally Thorade gives a comprehensive list of literature.

This very brief review can only indicate the contents of Dr. Thorade's valuable paper, which is indispensable to everyone who is interested in current measurements. It is to be hoped that it has been widely distributed, although it has appeared in a series which may be difficult of access to many physical oceanographers.

H. U. S.

B. Schulz. "Bericht über die Fortschritte der Ozeanographie (1929—32)". Geogr. Jahrb., Bd. XLVIII, S. 244—301. Gotha, 1933.

Professor Schulz has again given us the benefit of his industry in collecting references to books and papers dealing with the hydrological side of oceanography. As before, the references are arranged under two main heads, A, General and, B, Particular, and the division of these heads into subsections is made on much the same lines as hitherto. The references in the General section are classified under I. History, Organization, Expeditions and Bibliographies, II. Morphology and Geology (including methods of sounding), III. Physics and Chemistry of Sea Water, IV. Movements of the Sea Water (currents, tides and waves). In part B, the four subsections relate to the Pacific, Indian, Atlantic (here there are many further regional subdivisions, including north polar waters) and Antarctic Oceans.

Following each subsection is a brief note indicating the main trend that the work has taken during the period covered. The two earlier reports of this series took the form rather of a documented summary, in which the references were given in copious footnotes, than of a bibliography, and the present style seems to me a distinct improvement, in making this valuable work of reference more easily handled.

J. R. L.

L. Möller. "Methodische Untersuchungen und Neubestimmungen der Konstanten des Meerwassers". Ann. d. Hydrogr. usw., LXI Jahrg., H. I u. II, p. 22—24, Berlin, 1933.

In this article the author describes the work on the re-determination of the constants of sea-water that has been carried out since 1928 by the "Physikalisch-Technische Reichsanstalt" and the "Institut für Meereskunde". A preliminary report on the methods used in this work has been given by Willy Bein, Heinz-Günther Hirsekorn and Lotte Möller in this Journal, Vol. VIII, p. 48.

The article in Ann. d. Hydrogr. states that in certain cases modern hydrographical work demands a higher accuracy of the density-determination of sea-water than can be obtained by chlorine titration and the use of Knudsen's Hydrographical Tables.

As regards the Mediterranean and the Red Sea the author suggests that the differences $\sigma_{t,\,grav.} - \sigma_{t,Cl}$ ($\sigma_{t,\,grav.}$ represents the density determined by gravimetrical methods and $\sigma_{t,\,Cl}$ represents the density calculated from chlorine titration by means of Knudsen's tables) amounts to —0.1. On the other hand the author states — referring to Sverdrup — that the difference $\sigma_{t,\,grav.} - \sigma_{t,Cl}$ may be supposed to be positive for the waters of the North Siberian shelf.

Undoubtedly the difference $\sigma_{t.\,grav.} - \sigma_{t,Cl}$ may amount to $|0.01|$ or $|0.02|$ but, from what has been known hitherto, the value —0.1 of the difference $\sigma_{t,\,grav.} - \sigma_{t,\,Cl}$ seems numerically too high for the Mediterranean and the Red Sea. According to the determinations of the chlorine content and the density of the samples from the Mediterranean and the Red Sea in 1899/1902 the value of $\sigma_{0,\,grav.} - \sigma_{0,Cl}$ should amount to no more than $|0.01|$ or $|0.02|$ and according to the investigations of samples from the Mediterranean by Thomas G. Thompson and Henry E. Wirth (Jour. du Conseil, VI, p. 232) the difference $\sigma_{0,\,grav.} - \sigma_{0,\,Cl.}$ should be 0.014 i. e., of opposite sign to that suggested by the author.

Similar values were found for samples from the Mediterranean by E. Ruppin (Publ. de Circ. Nr. 55, 1910).

According to H. U. Sverdrup the average of about 600 determinations of the difference $\sigma_{t,grav} - \sigma_{t,Cl}$ for the waters of the North Siberian shelf amounted to 0.02.

The full description of the investigations and results, which, it is announced, are to be published in: "Wissenschaftl. Ergebnisse der Deutschen Atlantischen Expedition auf 'Meteor' ", Bd. VII, 2, embracing not only the gravimetrical methods for density determination but also methods based on optical refraction and electrical conductivity, will be of the greatest interest to all Hydrographers.

J. P. Jacobsen.

H. Wattenberg. "Das chemische Beobachtungsmaterial und seine Gewinnung. Kalziumkarbonat- und Kohlensäuregehalt des Meerwassers". Wiss. Ergebn. Deutsch. Atlantischen Expedition "Meteor". Bd. VIII. Berlin u. Leipzig, 1933.

I. Das chemische Beobachtungsmaterial und seine Gewinnung.
This section is a description of methods and equipment, and a Station List.

II. Über die Titrationsalkalinität und den Kalziumkarbonatgehalt des Meerwassers.

This report opens with a very thorough and critical review of the existing literature of the calcium carbonate and alkalinity system and of the biological and geochemical problems in need of solution. The titration alkalinity or excess base present in sea water has considerable biological importance for its own sake. On the "Meteor" Expedition, however, its determination was undertaken on an extensive scale for the light it might shed on the distribution of CO_2 and $CaCO_3$ in the sea. In the result, Wattenberg's hopes have been more than justified. The work demanded titrations of a high degree of accuracy, to attain which he used a very neat and rapid method. In order to drive off the CO_2, a current of air, freed from CO_2, was passed through the boiling sea water to which had been added a measured excess of hydrochloric acid. The excess was titrated with baryta to the very sharp colourless end point given by a mixed methyl red-brom cresol green indicator.

The ratio titration alkalinity/chlorinity was defined as the "specific alkalinity", and from the variations in this he was able to deduce the distribution of calcium throughout the South Atlantic.

In low latitudes the calcium content decreases from the surface to a minimum at 100 metres, and the normal content is reached again at 1,000 metres.

In water below 2,000 metres the specific alkalinity, and consequently calcium, increases with depth and particularly rapidly immediately over the bottom. This is traced to re-solution of bottom deposits of calcium carbonate. Also, the greater the depth the greater the rate of increase of specific alkalinity near the bottom and the further from the bottom does the region of rapid increase extend. Thus in depths of 2,000 metres the region of rapid increase begins only 50 metres above the bottom, in 3,000 metres 400 metres from the bottom, whilst in 5,000 metres the increase starts more than 1,000 metres up. These results are due to the greater solvent power of the water for calcium carbonate under great pressure. This subject is also treated theoretically. A clear relation is traced between the presence or absence of limy bottom deposits and the degree of unsaturation of the supernatant water with regard to calcium carbonate.

This relative increase in the content of calcium carbonate of deep water introduces a small error into the values of the density derived from Knudsen's Hydrographical Tables. It is true that at 5,000 metres the error in σ amounts only to 0.005 but it is probably greater at greater depths and is greater than the error in direct determinations of σ with the Nansen immersion areometer. It may be of importance in refined dynamical investigations at great depths.

Several theoretical investigations, based on the equilibrium constants applying for solutions of calcium carbonate at infinite dilution in pure water, have indicated that sea water is many times supersaturated with this substance. This has been at variance with the facts that at atmospheric pressure the degree of supersaturation of sea water is not more than about 50 %. Wattenberg has shown that the discrepancies can be accounted for on the modern physico-chemical theory of electrolytes. Since the activity of any ion is affected by the electric charges on surrounding ions it is necessary to work with the thermodynamic or activity constant (cf. also the work of K. Buch). He has also calculated the ionic strength of sea water, his value for which should be of value in many other similar investigations. The theory fits well with the experimental facts both of Wattenberg and of other investigators.

Surface water in the open sea in the tropical and temperate zones is always somewhat supersaturated with calcium carbonate but the degree of supersaturation is less the lower the pH, the lower the temperature and the greater the depth. The higher degree of supersaturation in the tropics no doubt greatly assists the deposition of the calcareous skeletons of corals and calcareous plankton.

III. Untersuchungen über den Kohlensäuredruck und die Wasserstoffionenkonzentration des Meerwassers.

This section also opens with an account of the problems awaiting solution and with a physico-chemical treatment of the CO_2 system based on the activity constants of carbonic acid, pH, temperature and pressure. Allowance has been made for that part of the alkalinity due to borate.

The direct determination on board ship of the very small partial pressures of CO_2 in sea water is by no means an easy task. The sea water in a shaking bottle at a known temperature was brought into equilibrium with air. This air was thus transferred through a capillary rubber connection to a measuring pipette, the graduations on which corresponded to $1:10^4$ of the total volume. This pipette was connected through a very sensitive differential oil-drop manometer with a compensating pipette at atmospheric pressure; thus the small decrease in volume (equivalent to a small decrease in partial pressure at constant volume) could be measured after absorption of the CO_2 by alkali. There remained but to correct this figure to the temperature of the sea water *in situ*. The relation found between the empirical values of partial pressure of CO_2 and of pH agrees well with that calculated from the formulae of Buch *et alia* (Rapp. et Proc.-Verb., Vol. 79).

Table 43, which gives a comprehensive record of pH values as measured and as corrected to the temperature of the water *in situ* and of calculated partial pressures of CO_2, would have been somewhat clearer if it had been stated that none of the pH values have been corrected for pressure.

The volume includes a series of charts giving the vertical distribution of pH and partial pressure of CO_2 along the various profiles run and

the horizontal distribution at different depths. The partial pressure in the surface waters nowhere departed far from that in the atmosphere ($3 \cdot 10^{-4}$ atmosphere) but great variations were found in deeper water. Under the permanent thermocline off the African coast in about 10° S. lies a nucleus of water exceptionally rich in CO_2. The maximum effect is found at about 400 metres where the partial pressure reaches as high as $12 \cdot 10^{-4}$ atm. and the pH falls to 7.65. This accumulation of CO_2 is due to the oxidation of organic material and a relationship is traced between the plankton content of the water at different depths and the subsequent CO_2 production. The relationship becomes very close indeed when allowance is made for the temperature coefficient of the rate of oxidation at different depths.

The North Atlantic deep water shows a low partial pressure of CO_2 which increases slowly as the water travels southwards. In chemical properties as in salinity Arctic and Antarctic bottom waters contrast sharply; while the former contains little CO_2 (partial pressure less than $3 \cdot 10^{-4}$ atm.) almost the whole of the Antarctic basin below 400 metres is filled with water of partial pressure greater than $5 \cdot 10^{-4}$ atm. The strong solvent action on calcareous bottom deposits of this acid Antarctic bottom water as it flows northwards has a profound geochemical importance.

In the space of a short review it is possible to do scant justice to the great mass of experimental data and physico-chemical argument which make up these reports. Their presentation is noteworthy for the directness of treatment and for the simplicity and conciseness of the language; there seems not a word too few, not a word too many. They may be recommended to the foreigner whose German, like the reviewer's, is not as good as it might be.

L. H. N. C.

E. Krebs and M. Osadchih. "The Organic Phosphorus in the Sea". Internat. Rev. d. ges. Hydrobiol. u. Hydrogr., Bd. 29, H. 3—4. Leipzig, 1933.

Während über die anorganischen Nährsalze des Planktons, besonders das Phosphat ein sehr grosses Beobachtungsmaterial vorliegt, wusste man bis vor kurzem über den organisch gebundenen Phosphor so gut wie nichts. Der organisch gebundene Phosphor im Meere setzt sich zusammen aus dem im Plankton (und anderen Organismen) verkörperten Phosphor und den im Wasser gelösten P-Verbindungen, die nach dem Absterben des Planktons freiwerden. Dieser "organische Phosphor" wird bisher immer zusammen bestimmt, obwohl eine Trennung in die beiden genannten Anteile von Interesse wäre. Wie sehr nähere Angaben über den organischen Phosphor im Meere vermisst wurden, geht schon daraus hervor, dass seine Untersuchung fast gleichzeitig von drei verschiedenen Seiten in Angriff genommen wurde[1]).

Die Bestimmungen der Verfasser — die durch H. W. Harvey angeregt wurden — erstreckten sich auf das Oberflächen- und Tiefenwasser der Barentssee von Juli 1931 bis Januar 1932 und wurden nach der etwas modifizierten Methode von Robinson und Kemmerer ausgeführt. Im allgemeinen war die Verteilung des organischen Phosphors ähnlich der des Phosphats, also die Konzentration in der Tiefe grösser als an der Oberfläche, im Winter grösser als im Sommer. Im Sommer und Herbst beträgt die Menge des organischen Phosphors weniger als die Hälfte des

[1]) K. Kalle, Ber. Deutsch. Wiss. Komm. f. Meeresf. N. F., Bd. 6, S. 273—99 (1933). H. R. Seiwell u. G. E. Seiwell, Ann. d. Hydrogr. usw., Bd. 62, S. 7—13, (1934).

anorganischen, im Winter dagegen ist mehr organisch gebundener Phosphor als Phosphat vorhanden. Die Verfasser vermuten, dass die Schicht dicht über dem Boden sehr viel organischen Phosphor enthält, der aus den abgestorbenen und abgesunkenen Organismen freigeworden ist. Diese Schicht, die mit den bisherigen Schöpfmethoden nicht erfasst wurde, soll noch näher untersucht werden, ebenso bedarf das Bestimmungsverfahren für den organischen Phosphor noch weiterer Ausarbeitung. Aber schon diese vorläufige Mitteilung gibt einen interessanten Einblick in den komplizierten Vorgang der Regeneration der anorganischen Nährstoffe des Planktons.

H. W.

L. H. N. Cooper. "Chemical Constituents of Biological Importance in the English Channel. Pt. III. June—December, 1932. Phosphate, Silicate, Nitrite, Hydrogen-Ion Concentration, with a Comparison with Wind Records". Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 1. Plymouth, 1933.

Die Untersuchungen bilden die Fortsetzung der kürzlich referierten Arbeiten[1]), die sich von Nov. 1930 bis Jan. 1932 erstreckten. Während des August 1932 trat eine merkwürdige doppelte Schichtung der Wassermassen auf. Starke Winde Ende Juli hatten das Wasser bis 10 m. Tiefe gemischt, und das folgende sonnige Wetter hatte eine zweite Sprungschicht dicht unter der Oberfläche erzeugt. Die zwischen den Sprungflächen eingeschlossene Schicht zeichnete sich durch abnorme chemische Verhältnisse aus.

Auch sonst fand der Verfasser, dass die Windverhältnisse eine grosse Bedeutung für die chemischen und biologischen Eigenschaften des Wassers besitzen. So fand er, dass in drei von vier Fällen eine Planktonentwicklung mitten im Winter mit vorhergehendem ungewöhnlich ruhigen und sonnigen Wetter zusammenhing. Als ein Mass für die mischende Wirkung des Windes wird die dem tatsächlichen Winddruck proportionale dritte Potenz der Beaufort-Stärke benutzt. Darnach hat z. B. ein Wind von Stärke 6 eine acht mal so grosse Wirkung wie ein Wind von Stärke 3. Schliesslich wird der offenkundig vorhandene Einfluss von stürmischem Wetter auf die Bodenfauna und auf die Erträge der Fischerei diskutiert.

H. W.

R. S. Wimpenny. "Variations in North Sea Plankton, 1923—24". Min. of Agric. and Fish., Fish. Invest., Ser. II, Vol. 13, No. 3, 1933. London 1933.

Die Untersuchungen bezogen sich auf die "Flamborough-Linie" zwischen Flamborough Head und der Doggerbank (4 Fahrten) und auf eine nördlichere Linie zwischen der Tynemündung und dem Südende Norwegens (3 Fahrten). Aus Vertikalzügen mit Hensen- und Apsteinnetzen wurden Werte für je 1 m.^{3} berechnet.

Das Phytoplankton zeigte auf der Flamborough-Linie das Maximum im März, das Minimum im Oktober. Über der Küstenbank und besonders der Doggerbank erwies es sich als reicher als in den tieferen Zwischengebieten. Die Diatomeen sind meist bedeutend zahlreicher als die Peridineen, letztere nehmen nach Osten zu. Die Untersuchung der einzelnen Arten ergab Wucherungen der Diatomeen vorwiegend im (Februar und) März, der Peridineen *(Ceratium)* von August bis Oktober. Das Zooplankton hat ein bedeutendes Maximum im August, was vielleicht von Einfluss auf die

[1]) Journal du Conseil, VIII, 3, S. 392.

Heringsbestände ist. Es ist reicher an Stellen tieferen Wassers, wohl infolge von Zufuhr von Norden her. *Temora longicornis* und *Calanus finmarchicus* sind die vorherrschenden Arten. Ihr prozentualer Anteil am Plankton und am Inhalt von Heringsmägen wird untersucht. *Calanus* ist wohl von Norden her über seine eigentliche Südgrenze (56° N. Br.) hinweg zugeführt, *Temora* endemisch. Einheimische Arten halten sich vielleicht im Gebiet durch zeitweises Herabsinken auf den Boden. Es ist beachtenswert, dass der Planktonreichtum von 1923 zusammentrifft mit Reichtum an überlebender Schellfischbrut.

Auf den nördlicheren Schnitten zwischen England und Norwegen liegt ein Maximum des Phytoplanktons nahe England, wohl infolge vertikaler Mischungen, wie auch ein zweites Maximum am Rande der Grossen Fischerbank. Es wird angenommen, dass die Planktonproduktion vom Skagerak ausgehend sich "Hexenring"-artig bis hierher ausgedehnt hat, wofür auch spricht, dass hier Diatomeen vorherrschen, weiter im Osten die ja meist später auftretenden Peridineen, und dass im Osten mehr Sporen gefunden werden. Die Fett speichernden Diatomeen werden im Sommer fortschreitend von Osten nach Westen durch Kohlehydrate speichernde Peridineen abgelöst. Der Diatomeenreichtum an der Nordküste Englands zur warmen Jahreszeit mag das Auftreten der fetten, reifen Heringe dort bedingen. An Zooplankton zeigte eine der drei Reisen zwischen England und Norwegen bedeutend mehr als die anderen, wohl weil sie zum Teil viel nördlicher verlief. *Calanus finmarchicus* herrschte stark vor. Das Zooplankton scheint rings um die Nordsee von West nach Ost verschleppt zu werden. *E. H.*

S. G. Gibbons. "A Study of the Biology of *Calanus finmarchicus* in the North-Western North Sea". Fisheries, Scotland, Sci. Invest., 1933, No. 1. Edinburgh, 1933.

Die Arbeit schliesst sich an die Untersuchungen von Gran, Damas, Paulsen und Farran über das Leben von *Calanus finmarchicus* in den verschiedenen Teilen des Nordatlantischen Ozeans an. Das Untersuchungsgebiet liegt einerseits zwischen 57° und 61° N. Br., andererseits zwischen 0° und 4° W. L. und wird in einen nördlichen und einen südlichen Abschnitt geteilt. Alle anderen Copepodenarten treten hier der Individuenzahl nach und ganz bedeutend dem Volumen nach hinter *C. f.* zurück.

Die Metamorphose der Art wird in Text, Tabellen und Abbildungen übersichtlich dargestellt und ihre Kenntnis ergänzt. Im Laboratorium wurden Erwachsene in Bechergläsern von 1 l. Wassergehalt bei möglichst konstanter Temperatur und Fütterung mit Chlorodendron bis 41 Tage lang gehalten. Aus abgelegten Eiern schlüpften die Nauplien (im Juli) nach 65—75 Stunden aus. Das letzte (fünfte) Copepoditstadium zeigt noch keine Geschlechtsunterschiede, was festgestellt werden konnte, indem bei isolierten Individuen dieses Stadiums die letzte Häutung abgewartet und dann die Häute von Männchen und Weibchen verglichen wurden. Die erwachsenen Weibchen sind im Februar kleiner als im Sommer und ärmer an Öltropfen. Weibchen können noch Eier ablegen, nachdem sie wenigstens drei Wochen lang ausser Verbindung mit Spermatophoren gewesen sind. Die Befruchtung geschieht augenscheinlich schon im Körper des Weibchens.

Im Untersuchungsgebiet sind im Jahresmittel die späteren Copepoditstadien häufiger als die früheren. Das deutet, da man infolge der natürlichen Sterblichkeit das umgekehrte erwarten sollte, auf Zufuhr von aussen her hin. Die Bevölkerung ist im Winter spärlich. Copepoditen und Erwachsene erreichen in beiden Abschnitten ein Maximum im Mai, im Südabschnitt ein zweites

Maximum im September. Die Nauplien erreichen Maxima im Nordabschnitt im Juni und August, im Südabschnitt im April und August. Die Häufigkeit der verschiedenen Stadien in den verschiedenen Monaten ist tabellarisch dargestellt. Die verwickelten Umgestaltungen der Bevölkerung von Monat zu Monat beginnen mit reicher Nauplienbildung im April und folgendem Anschwellen der Jugendstadien im Mai. An dieser Zunahme ist aber zunächst im Nordabschnitt, später auch im Südabschnitt starke Zufuhr von Norden her beteiligt. Im Norden sind bis Juli die Weibchen herangewachsen, weshalb im August viele Nauplien auftreten, die auch in den Südabschnitt verfrachtet werden. Dass das Septembermaximum im Südabschnitt keine wesentliche Nauplienproduktion mehr zur Folge hat, dürfte an den ungünstiger werdenden Ernährungsbedingungen und an der weiteren Wegführung südwärts, wo viele Erwachsene absterben, liegen.

Diese Bevölkerungsbewegung von *C. f.* unterscheidet sich von derjenigen in anderen Gebieten, insbesondere bei Norwegen hauptsächlich infolge des Fehlens von tiefem Wasser, in dem die Copepoden überwintern könnten.

E. H.

O. M. Jorgensen. "On the Marine Cladocera from the Northumbrian Plankton". Journ. Mar. Biol. Assoc., N. S. Vol. XIX, No.1. Plymouth, 1933.

In this investigation the individuals of the genus *Podon* have not been referred to their species owing to the difficulty of their identification in a routine plankton analysis. Similarly, no special effort has been made to distinguish rarely occurring individuals of *Evadne spinifera* which it is thought may have been present. The first part of the paper is, therefore, concerned with a general consideration of the occurrence of the genera *Podon* and *Evadne* in the Northumbrian plankton and a particular discussion of the problems of distribution and fluctuations in population of the commonest species, *E. nordmanni.*

The data consist of hauls taken between the spring and autumn during the years 1921—1930 inclusive and show the existence of early summer and autumm maxima for the genus *Podon* and *Evadne nordmanni.* For *Podon* the autumn maximum is the greater, but for *Evadne nordmanni* the reverse is the case. In both cases resting-eggs were taken most frequently at the periods of densest population.

The author explains the two maxima of *Evadne nordmanni* as the normal state of things when the species migrates inshore and across the stream which would otherwise have borne it passively down the coast. In this inshore environment a rapid succession of parthenogenetic broods are produced. Towards the end of the maximum fewer embryos are produced in each brood pouch and sexual reproduction with the occurrence of males indicate the end of the parthenogenetic phase. This cycle of events occurs twice.

Exceptionally, in 1921, 23, 27 and 29 — four years out of the ten investigated — the periods of abundance of *Evadne nordmanni* are thought to have been advanced and the occurrence of resting spores inhibited. This is thought to have been due to unusually strong or differently constituted currents which hindered the inshore migration and subsequently swept the *Evadne* population away, thus in some years preventing the autumn maximum and always curtailing the reproductive cycle. The exceptional conditions in the current systems for 1921, 27 and 29 were characterised as Atlantic inflows of unusual strength; in 1923 an Arctic inflow was suggested as responsible. The reviewer would have welcomed a fuller

discussion of the current régime in the North Sea, particularly in connection with the definition of a "normal" year in contrast with an "exceptional" one. A series of horizontal hauls confirmed the epiplanktonic nature of *Evadne nordmanni*.

The second part of the work consists of an account of the development of the parthenogenetic and sexual generations of *Evadne nordmanni*. The development of the ova in the sexual generation is shown to be preceded by the formation of tetrads and there is indirect evidence that such is also the case in parthenogenetic development. In both parthenogenetic and sexual reproduction the nurse cells are found to be produced by the wall of the brood chamber.

The behaviour of females stained with neutral red and osmic acid is interpreted as showing that fat is the characteristic food reserve of the sexual phase and glycogen that of parthenogenesis.

Miss Jorgensen concludes with an interesting discussion on the explanations of the life-cycle in Cladocera in relation to environmental and hereditary factors. She appears to agree with Woltereck in considering that there is an inherent cyclicity which may be modified by environment. In the case of *Evadne nordmanni* the species is considered to be dicyclic in the Northumberland coast neighbourhood and the two periods of parthenogenetic reproduction are thought to be directly related to nutrition and only indirectly perhaps to temperature. In this connection it is shown that these two periods correspond with the spring and autumn phytoplankton maxima.

While the reviewer cannot but agree that the explanation of the two periods of abundance in *Evadne nordmanni* may be due to distribution by currents and the effect of abundant food supply on a dicyclic species, he would point out the possibility of the same distribution being presented by a monocyclic species whose different elements drifted inshore to a rich feeding ground at two different times of the year.

In other words, it does not seem safe to draw inferences from the data discussed that would only be made safely from a static population. Another concept which has been found difficult is that of understanding how a tiny and so truly planktonic an organism as *Evadne* can make transnatant migrations.

R. S. W.

A. Klem. "Contributions to the study of the oils of marine crustacea. I. The oils of *Meganyctiphanes norvegica* M. Sars and *Calanus finmarchicus* Gunn." Norske Vid.-Akad. Oslo, Hvalrådets Skr., Nr. 6, Oslo, 1932.

Marine oils are similar in respect of certain fatty acids mainly unsaturated and of which $C_{16}H_{30}O_2$ — "Zoomarine" — and $C_{22}H_{34}O_2$ — "Clupanodonic" — are notable. The writer of the paper under review is of the opinion that these resemblances are due to similar food, in the first instance zooplankton and ultimately marine plants. His purpose has been to examine two zooplankton species, the food of whales.

The work deals with oils extracted from three samples of *Calanus* and one of *Meganyctiphanes*. Of the *Calanus* samples, two were taken by tow-nets, five and seventeen miles northwest of Björnsund Lighthouse in May 1929 and in June 1930. The third was from the stomach of a Sei-whale at Aukra whaling station in June 1929, and the *Meganyctiphanes* sample was from the stomach of a Fin-whale at the same station in the summer of 1931.

The material from whale stomachs was boiled, but the rest was transferred direct into the extracting medium. Extraction was first with acetone, which was then treated with NaCl and the extraction continued with petroleum ether which was subsequently evaporated off in an atmosphere of dry CO_2.

The largest sample of oil thus produced was 123 grammes from the *Meganyctiphanes* material. This was converted into the methyl ethers and separated by fractional distillation into 74 different parts of which saponification and iodine values were separately determined.

This array of data enabled interesting estimates of the molecular weights and numbers of double bonds of the fatty acids to be made and charted. The chart shows the relation between molecular weight and number of double bonds per molecule (or degree of desaturation) to be expressed as a slightly sigmoid curve showing an increase of desaturation up to the C_{20}—C_{22} acids. These operations also showed the presence of myristic, palmitic, oleic and hexadenic acid (probably zoomarine) in the first eight of the twelve secondary distillation fractions. Stearic acid and saturated acids with molecular weights greater than palmitic are not to be considered as present in anything more than very small quantities. An octobromide present is held to indicate that there may be arachidic, clupanodonic and probably gadoleic acids.

The *Calanus* oils were not fractionated, but the complete primary oil was examined for saponification value and iodine number. The iodine values for these three samples and a comparable sample of the initial *Meganyctiphanes* oil were as follows:

Calanus I	157.9
Calanus II	157.5
Calanus III	158.1
Meganyctiphanes	167.5

The author considers that the evidence of high iodine values in *Calanus* and *Meganyctiphanes* and the conjunction of high iodine value and molecular weight in *Meganyctiphanes* point to the oils examined as typically marine.

Mr. Klem concludes by a short but valuable discussion of the factors governing the composition of fat in organisms.

While fats were formerly classified into two main groups, those of terrestrial and marine animals, Halder has divided them into two groups corresponding to the zoologists' divisions of warm and cold-blooded animals, the iodine value and liquidity of the fats being higher in the latter.

Among the warm-blooded animals fats of penguins and polar bears have an unusually high iodine value. Though Halder cites this as an effect of high latitude similar to that known to obtain in plants, the author suggests that marine food is the cause and brings forward several cases in which the nature of the food fat is shown in the fat laid up in the tissues of the feeder.

The author's attitude to the whole matter is best summed up in the words of his last sentence: "Thus the variations in the composition of a fat as a result of differences of temperature (climate) and food, do not express anything beyond the fact that the organisms concerned adapt themselves — in the matter of fats as in other respects — to their environment".

R. S. W.

H. B. Moore. "Faecal pellets from marine deposits". Discovery Reps. Vol. VII, pp. 17—26. Cambridge, 1933.

Die "Kotperlen[1])"-faecal pellets verschiedener Tierarten bilden, namentlich auf weichem Grund, oft einen wesentlichen Anteil am Sediment. Die häufigsten Kotperlen haben eiförmige Gestalt, daneben kommen auch stäbchen- oder röllchenförmige Körperchen vor. Die Konsistenz ist ziemlich fest, sodass die Kotperlen jahrzehntelang erhalten bleiben und selbst fossil nachgewiesen werden könnten. Das gilt namentlich für die eiförmigen Körperchen, welche dieselbe Zusammensetzung wie das Sediment selbst haben. Es ist das Verdienst von H. B. Moore, zuerst nachgewiesen zu haben, dass diese auch im Clyde vorkommenden Kotperlen von Maldaniden stammen (1931). Zudem hat Moore eine Reihe von Kotkörperchen verschiedener Tierarten untersucht und beschrieben mit dem Ergebnis, dass die Artzugehörigkeit der Kotperlen und Kotschnüre genau bestimmt werden kann. Offenbar ohne dass die beiden Autoren voneinander wussten, hat auch A. Schwarz (1932, Senckenbergiana, Bd. 14, Nr. 3, S. 118—172) "Kotpillen" und deren Ablagerung von verschiedenen Tierarten des Wattenmeeres bei Wilhelmshaven beschrieben.

In der vorliegenden Arbeit gibt Moore eine Literaturübersicht über die Beschreibung rezenter und fossiler Kotperlen und ihre meist irrtümliche Deutung seitens der Autoren. Daran schliesst sich die Beschreibung der Kotperlen im Material der "Discovery" an. In Planktonfängen waren Kotperlen von *Euphausia superba* häufig, wurden aber am Boden niemals gefunden. Dagegen waren im Sediment bis zur Tiefe von 4224 m. eiförmige, wahrscheinlich von Polychäten stammende Kotperlen häufig und daneben weniger zahlreich stäbchenförmige Kotperlen, welche vermutlich einer *Nucula*-Art angehören. Die Menge der Kotperlen in einem cm.^{3} des Discovery-Materials ist gegenüber den Ablagerungen im Clyde für die eiförmigen Körperchen geringer, für die stäbchenförmigen höher. Den an marinen Sedimenten arbeitenden Biologen und Geologen wird die Arbeit Moore's sehr willkommen sein. *A. H.*

F. Hecht. "Der Verbleib der organischen Substanz der Tiere bei meerischer Einbettung". Senckenbergiana, Bd. 15, Nr. 3—4. Frankfurt a. M., 1933.

Die Frage nach der Art des Abbaus der organischen Substanz im Meere und nach ihrem Verbleib hat mannigfache Bedeutung. Zunächst spielt sie allgemein im Haushalt der Meere eine wesentliche Rolle, und für das eingebettete Material hat sie neben der biologischen auch eine allgemein sedimentkundliche und eine besondere Bedeutung zur Erklärung der Erdöle. Um sie der Lösung näher zu bringen, hatte sich der Verf. die Aufgabe gestellt, die in der Natur *tatsächlich* vor sich gehenden Umwandlungen zu untersuchen und sich nicht auf die *möglichen* Erscheinungen des Laboratoriumsversuchs zu beschränken. Er hat gleichartige Proben im Watt des Jadegebietes in verschiedenartigen Sedimenten, in verschiedenen Tiefen und ausserdem verschiedenartiges Material unter gleichen Bedingungen mit besonderen Vorsichtsmassregeln vergraben und dann in gewissen Zeitabständen die Proben untersucht. Bei der Zersetzung benutzt er die Begriffe Verwesung, die bei Anwesenheit von Sauerstoff eintritt und als Endprodukt einfachste anorganische Verbindungen aufweist, und Fäulnis, die ein Fehlen von

1) Anm. Die Bezeichnung "Kotperlen" stammt von Dr. Wohlenberg-Helgoland.

Sauerstoff voraussetzt, und mit der Bildung fossil erhaltungsfähiger organischer Stoffe endigt. Somit ist für die Überlieferung von organischer Substanz nur die Fäulnis von Bedeutung. Versuche im Meerwasser haben gezeigt, dass nur sehr hoher H_2S-Gehalt restlos allen Sauerstoff binden kann, sodass Fäulnis auftritt, sonst ist immer, selbst in Wasser mit hoher Salzkonzentration Verwesung beobachtet. Allgemein am wenigsten widerstandsfähig sind die Eiweisstoffe, sie liefern grosse Gasmengen bei der Zersetzung und unbedeutende Mengen von niederen Fettsäuren. Die Gerüsteiweisstoffe — also Chitin, Keratin, Konchyolin, Spongin und ähnliche Stoffe — sind dagegen nicht nur in Wasser, Salzlösungen, sondern auch in tierischen Säften und meist in verdünnten Säuren und Alkalien unlöslich und zeigen sich daher ausserordentlich widerstandsfähig. Ein wesentlicher Teil des Stickstoffs der Sedimente ist auf diese Stoffe zurückzuführen. Die Fettanteile der tierischen Körper sind ebenfalls recht ausdauernd. Der Verf. konnte zeigen, dass selbst ungesättigte Fettsäuren im Laufe von 10 Jahren chemisch nicht verändert wurden. Die Fette können durch eine relative Anreicherung zur Bildung von Leichenwachs führen. Dagegen glaubt der Verf. nachweisen zu können, dass entgegen den Ansichten anderer Autoren Leichenwachs, das aus Fetten mit Stearin-, Palmitin- und Ölsäure-Basis besteht, nicht aus Eiweiss entstehen kann und dass somit eine Bildung von Anabitumen auf diesem Wege nicht möglich ist.

Für die Fäulnis ist das Sediment sehr wichtig, und ein Abschnitt befasst sich mit den Wechselbeziehungen zwischen organischer Substanz, Urbitumen, Sediment und Tierwelt. Unter Urbitumen wird die amorphe Substanz verstanden, die im Sediment aus der Gesamtmasse der ursprünglichen Weichteile hervorgegangen ist. Es wird durch den Kot der Aasfresser und Raubwürmer vermehrt und seine Menge kann durch Sedimentationsfaktoren abgewandelt werden. Die Untersuchungen nach der Natur des Urbitumens kamen in Übereinstimmung mit amerikanischen Befunden zu dem Ergebnis, dass in den Wattsedimenten noch keinerlei Erdöl-verwandte Stoffe auftreten. Deshalb wurden die aktuo-geologisch bestimmten chemischen Untersuchungen eingestellt. Bei der Frage nach der Herkunft grosser Mengen von Urbitumen bzw. Erdöl wurde auf die grosse Bedeutung der Kotsubstanzen neben den Planktonleichen hingewiesen. Ausserdem muss die organische Substanz möglichst rasch der oberen Umlagerungszone des Sedimentes entzogen werden. Dies wird durch eine synsedimentäre Absenkung erreicht.

In einem letzten Abschnitt wird die Anlösung der Hartteile durch die organische Substanz und das Meerwasser besprochen, wobei vor allem Kohlensäure und u. U. auch Schwefelsäure die Kalkskelette angreifen, sodass die chemische Zerstörung oft fast ebenso schnell wie die mechanische vor sich geht.

Die chemische Aufarbeitung zeigt Anätzung und Anlösung, die mechanische hinterlässt Zeichen der Abrollung und des Zerbrechens bzw. Abbrechens. Da die mechanischen Beeinflussungen Bewegungsvorgänge sind, lassen sich hierdurch allochthone und autochthone Ablagerungen unterscheiden. Die Anlösung kann weiter zum Biegsamwerden der Hartteile führen, sodass fossil gelegentlich angetroffene Verbiegungen und bruchlose Verzerrungen hierdurch ihre Erklärung finden.

Die Untersuchungen, die auf zahlreiche Untersuchungen und Analysen aufgebaut sind, lassen uns manche Vorstellung von Fossilwerden jetzt in ihren Einzelteilen erkennen. Was früher Vermutung war, konnte nun bewiesen, und bei einander gegenüberstehenden Meinungen konnte eine Entscheidung getroffen werden. Allerdings muss man sich vor Augen halten, dass es sich um Wattbeobachtungen handelt, also um Verhältnisse, die nicht

völlig identisch mit denen der offenen Meere sind, sowohl was die Höhe der Wasserbedeckung und der dadurch bedingten atmosphärischen Beeinflussung wie auch was die Sedimentationsbedingungen und nicht zuletzt was die Besiedlung betrifft. Das ist keine Schmälerung der vorzüglichen Arbeit, sondern nur ein Hinweis, sie auch auf andere Gebiete auszudehnen.

Pratje.

F. S. Wright. "Report of Investigations into the past and present condition of the Natural Oyster Beds of South Wales including a brief account of experimental work undertaken towards the improvement of the oyster fishery". Min. of Agric. and Fish., Fish. Invest. Ser. II, Vol. XII, No. 4, 1932. London, 1932.

This report gives an account of investigations on the condition of the natural oyster beds in the Bristol Channel off Swansea and Mumbles Head and those in Milford Haven. The serious decrease in yield of these beds since 1921 aroused the concern of the South Wales Fisheries Committee and led to the observations herein noted. These investigations are a symptom of the general desire of both British Fisheries Committees and Government Departments to improve the local shell fisheries where adequate information is available for the purpose.

The beds off South Wales are situated in open waters and are known to be liable to fluctuations in yield, as are all open water beds. Dredging operations in 1922 indicated serious depletion of most banks, though a fair stock was found in the locality of Stackpole. The conclusion was arrived at that the depletion was due to the poor spatfall in recent summers. Recommendations were made for improvement and protection of the beds, including the laying down of breeding oysters. Oysters were laid down on a protected bed, Roads Haul, in 1925 and an improvement found in the stocking of neighbouring banks during dredging investigations made in 1929. The author does not claim that these beneficial results are due with certainty to the experimental stocking of the beds, but rightly points out the desirability of continuing such experiments, especially in relation to the local set of the tides and known distribution of spatfall. In 1931 the beds in Milford Haven were examined sufficiently to indicate almost a barren condition on what appear to be very suitable grounds, especially in the River Cleddau. The author's suggestion for distributing breeding stocks in Penar Gut and the Cleddau, especially if reinforced by yearly additions of fresh cultch, might well help towards the restoration after a number of years of the Milford Haven beds, provided that the chemical and physical conditions of the water are as suitable as the sea bottom appears to be.

Final recommendations were made, including closing of certain areas of the grounds, the relaying of adult oysters to form a breeding stock, the deposition of cultch at an appropriate time, the return of young oysters to the beds, and prohibition of collecting along the foreshores. Some of these recommendations have apparently been adopted by the local Fisheries Committee. The author might very well have recommended also the institution of a local regulation definitely limiting the size of oysters which might legally be taken on the beds, and secondly a regulation enforcing the return of all natural cultch to that part of the beds from which it is taken, if such a regulation is not in exisence.

The problem of preserving oyster beds in open waters is a very difficult one owing to the capricious incidence of natural spatfalls in such waters. The greater the stocks of oysters in a locality the better are the chances of continuing spatfall on local beds. Therefore on depleted beds the primary

considerations in the reviewer's opinion are to retain stocks of breeding oysters on a suitable bed and to provide suitable material on appropriate parts of the grounds for the young to settle on. The author's recommendations cover these essential considerations with others in an interesting and useful report, which is, however, somewhat unrelated to recent modern work on the various aspects dealt with. *J. H. Orton.*

E. Ford. "An Account of the Herring Investigations conducted at Plymouth during the Years from 1924—1933". Journ. Mar. Biol. Assoc. N. S., Vol. XIX, No. 1. Plymouth, 1933.

Die umfangreiche Arbeit beginnt mit einem kurzen Überblick über den Gang der Heringsfischerei von Plymouth. Die Erträge zeigen sehr grosse Schwankungen, doch sind die Erträge der Nachkriegszeit grösser als die der Vorkriegszeit. Aus allen Vergleichen ergibt sich für die Beurteilung der Ertragsschwankungen, dass als Ursachen hierfür sowohl Zahl und Art der jeweils in der Fischerei tätigen Fahrzeuge wie auch die verschiedene Intensität der Befischung massgeblich sind. Daneben sind aber auch in der Natur gegebene Ursachen vorhanden, die aber vorläufig noch nicht ganz zu übersehen sind. Von besonderem Interesse sind die Feststellungen über den Zusammenhang zwischen heftigen Winden und den Fangerträgen in dem Sinne, dass diese nach Sturmperioden grösser waren als zu anderen Zeiten. Als mögliche Ursache hierfür wird genannt, dass in dem durch den Sturm aufgewühlten Wasser die Heringe die Netze nicht sehen und so leichter hineingeraten.

In ihrer Grösse, ihrem Gewicht und ihrem Alter sind die Plymouth-Heringe sehr verschieden. Obwohl nur einmal wirklich Heringslaich gefunden wurde, deuten doch die grossen Mengen "fliessender" Heringe und die Anwesenheit frisch geschlüpfter Larven darauf hin, dass sich die Laichgründe vor der Küste befinden. "Fliessende" Heringe sind über eine Zeit von $7^1/_2$ Monate hin festgestellt. Die Altersuntersuchungen bringen deutlich zum Ausdruck, wie der Bestand durch jüngere Jahrgänge erneuert wird. Die Körperlänge innerhalb einer Jahresklasse schwankt sehr stark. Eine der Ursachen hierfür sucht der Verfasser darin, dass die Heringe eines Jahrganges infolge des längere Zeit andauernden Laichens und Schlüpfens ein verschiedenes absolutes Alter haben und deshalb schon am Ende des ersten Lebensjahres in ihrer Körperlänge variieren. Es sind hier auch die bekannten l_1- und l_2-Berechnungen gemacht. Danach schwankt l_1 ganz erheblich, und dasselbe ist bei l_2 der Fall. Hieran schliessen sich nun weitere Berechnungen an, um den Zuwachs zwischen dem 1. und dem 2. Lebensjahre zu bestimmen. Es wird festgestellt, dass dieser Zuwachs um so geringer ist, je grösser der Wert l_1 ist und umgekehrt. Diese von Watkin als "kompensatorisches" Wachstum bezeichnete Erscheinung wird dann noch weiter in Anlehnung an die Untersuchungen von Hodgson besprochen. Es wird dann die Möglichkeit erörtert, durch derartige l_1- usw. Berechnungen das Wachstum in verschiedenen geographischen Gebieten zu bestimmen. Und hiervon wird wieder die Möglichkeit abgeleitet, aus Schuppenmessungen Rückschlüsse auf Wanderungen zu ziehen, eine Schlussfolgerung, die bereits von Lea gezogen wurde. Dass mindestens eine Unsicherheit in dieser Methode liegt, darf nicht unerwähnt bleiben. Die in der genannten Weise untersuchten Heringe aus dem Gebiet von Plymouth zeigen nach Ford teilweise den Wachstumscharakter der "atlantischen" Heringe, teilweise den der Heringe aus dem östlichen Kanal, und wieder andere ein "gemischtes" Wachstum. Es wird daraus der Schluss gezogen, dass die Laichgründe von Plymouth sowohl von Westen wie von Osten Zuzug erhalten.

Einen grossen Raum in dieser Arbeit nimmt die Erörterung der Frage nach den "Genotypen" beim Hering ein, bei der mancherlei gegensätzliche Auffassungen bestehen. Doch gerade dieser Umstand kann nur förderlich auf die künftige Lösung dieser Fragen wirken. F o r d stellt zunächst fest, was ja bereits aus allen früheren Untersuchungen hervorgegangen ist, dass die Heringe aus dem atlantischen Teil des Kanals eine höhere Wirbelzahl haben als die aus dem östlichen Teil des Kanals stammenden Heringe. Die aus den Gewässern von Plymouth stammenden Proben nehmen eine mittlere Stellung zwischen den beiden Extremen ein. In dem Gebiet VII g liegt das Maximum zwar bei "Klasse 5", doch sind hier die nach dem anderen Extrem hin liegenden Proben sehr häufig. Für diese Erscheinung reicht die Erklärung durch die allgemeine Regel der bestimmt gerichteten Veränderung der Wirbelzahl von Osten nach Westen nicht aus.

Nach einer kurzen theoretischen Erörterung des Begriffes "Rasse" geht F o r d zu einer eingehenden Prüfung der Frage nach dem Bestehen von Rassen überhaupt über. Diese Prüfung beginnt mit einer kritischen Betrachtung bisheriger Untersuchungen. Der Verfasser stellt nach der prozentualen Häufigkeit der Wirbel Klassen auf. Diese Klasseneinteilung ist allerdings künstlich, und wenn nach diesem künstlichen Schema die bisher als "Rassenmerkmale" angesehenen Variabilitäts-Typen eingeordnet werden, so liegt darin selbst dann eine Schwäche, wenn man die empirisch gefundenen Typen nicht als Rassenmerkmale anerkennt. Das ist aber zunächst unerheblich, denn als Schlussfolgerung wird aus diesen Erörterungen nur die Tatsache festgestellt, dass aus keinem Teil des in Frage kommenden Gebietes ausschliesslich solche Proben vorhanden sind, die einheitlich einen dem jeweiligen Gebiet zugeschriebenen Rassentyp darstellen. Von besonderer Wichtigkeit hingegen sind die genauen Analysen der in Plymouth gewonnenen Proben. Da das Laichen in den Gewässern von Plymouth von Ende September bis weit in den Frühling hinein andauert, ist, wie F o r d hervorhebt, an sich die Möglichkeit gegeben, dass dort mehr als eine Rasse laicht, ohne dass eine Überschneidung erfolgt. Bemerkenswert ist, dass die Mehrzahl der dort gewonnenen Proben nach dem Zustand der Gonaden verschieden und uneinheitlich ist. F o r d schliesst aus gewissen Anhaltspunkten, dass ein besonderes Laichgebiet für Heringe mit geringerer Wirbelzahl und früherer Laichzeit in der Nähe des Sundes liegt. Die Heringe ausserhalb des Sundes haben eine höhere Wirbelzahl und sind in jener Zeit noch nicht ganz laichreif. Die Wirbelzahl zeigt aber bei den Proben aus dieser Zeit Schwankungen, die nach F o r d keine bestimmte Beziehung zum Reifegrad haben. Von den als Beispiele angeführten Proben wird gesagt, dass sie "zum grössten Teil" Reifestadium VI aufweisen. Man darf wohl kaum Proben, in denen nicht *alle* Individuen "fliessend" sind, als repräsentativ für Laichschwärme ansehen. Die Schlussfolgerung, die F o r d aus dem Vergleich dieser Proben zieht, ist die, dass die Unterschiede in der Variabilität der Wirbel zu gross sind, als dass man sie als repräsentativ für e i n e Rasse ansehen könnte, obwohl sie "zur Hauptsache" aus Laichfischen bestehen, dass man aber auf der anderen Seite die Unterschiede auch nicht als Anzeichen für das Vorhandensein von zwei Rassen ansehen könne, ohne annehmen zu müssen, dass diese beiden Rassen zu gleicher Zeit im gleichen Gebiet laichen. Der erste Teil der Schlussfolgerung ist ohne Frage richtig, die Variabilität, besonders in ihren Extremen betrachtet, ist so gross, dass man die Proben nicht als repräsentativ für eine Rasse ansehen kann. Eine Schwäche in der Beweisführung liegt jedoch darin, dass die Proben nur "zur Hauptsache", aber nicht restlos aus laichreifen Individuen bestehen. Zur genauen Beurteilung fehlen die Angaben über den Prozentsatz der in jeder Probe enthaltenen nicht voll laichreifen Individuen.

Liegen die Proben in der Zeit ihrer Gewinnung weit auseinander, so wären auch die Fangdaten von Bedeutung.

Ford analysiert dann eine Probe von Laichheringen, und zwar von Weibchen mit fliessenden Eiern. Es wurde das Alter bestimmt, und die einzelnen Altersklassen oder -gruppen sind dann nach der Variabilität der Wirbel miteinander verglichen. Es zeigt sich hierbei die immer wieder beobachtete und ganz natürliche Erscheinung, dass, wenn man eine grosse Probe nach irgendwelchen Gesichtspunkten in einzelne kleinere Komponenten zerlegt, dann diese unter sich mehr oder weniger grosse Abweichungen zeigen. Diese sind auch hier ohne Frage vorhanden, die grösste Differenz zwischen den Mittelwerten der einzelnen Komponenten beträgt 0.33. Selbst wenn man die zahlenmässige Ungleichheit der Komponenten nur zu einem Teil, vielleicht sogar zu einem ganz geringen Teil für die vorhandenen Schwankungen verantwortlich macht und der Schlussfolgerung Fords zustimmt, dass zwischen einzelnen Altersgruppen Schwankungen vorhanden sind, so muss man sich doch die Frage vorlegen, wie das zu beurteilen ist. Berechnet man den Variations*modus,* so zeigt sich, dass sich dessen *Typ* bei den einzelnen Jahrgängen nicht so ändert, dass er grundsätzlich abweichende Bilder gibt. Dass verschiedene Jahrgänge gewisse Schwankungen zeigen müssen, ergibt sich daraus, dass jedes Merkmal das Produkt von Erbmasse *und* Umwelt ist. Es ist besser, nicht von der Erblichkeit oder Nichterblichkeit der *Merkmale* zu sprechen, als vielmehr von der Erblichkeit oder Nichterblichkeit der *Unterschiede* in den Merkmalen.

Die zweite von Ford eingehender analysierte Probe führt zu einer interessanten und neuen Feststellung. Die Männchen waren durchschnittlich kürzer als die Weibchen und hatten ebenso eine durchschnittlich niedrigere Wirbelzahl. Im Variationsmodus sind aber Männchen und Weibchen des Reifestadiums VI einander gleich. Diese Feststellung ist in Zukunft besonderer Beobachtung wert.

Von Bedeutung sind weiter die Untersuchungen an der 0-Gruppe. Ford macht zwei Feststellungen: 1) Die Zahl der Wirbel ist um so höher, aus je späterer Zeit die Proben stammen. 2) Bei Proben aus der gleichen Zeit ändert sich die Wirbelzahl mit der Länge der Fische. An dieser Feststellung an sich ist nicht zu deuteln. Zur Frage jedoch, ob die Wirbelzahl ein "Rassenmerkmal" oder ein reines Produkt "äusserer" Faktoren ist, können sie zunächst noch keine Entscheidung bringen. Selbst wenn man die Unsicherheit bei der Wirbelbestimmung an 30—35 mm. langen Fischchen ausser acht lassen wollte, so ist doch bei diesen Jungfischen für ihre genetische Herkunft kein sicherer Anhaltspunkt vorhanden. Dass eine starke Durchmischung der Jugendformen verschiedener Herkunft vorkommt, ist bekannt.

Bei der zusammenfassenden Besprechung geht Ford von der bekannten Tatsache aus, dass infolge der starken Durchmischung grosse Schwierigkeiten bestehen. Der "sample-number" wird die "race-number" gegenübergestellt. Eine willkürliche Zusammenstellung von "sample-numbers" zu einem "Typ" ist, wie Ford mit Recht betont, abzulehnen. Ein anderer Weg wäre der, die Proben zunächst nach besonderen Gesichtspunkten, z. B. den Reifegraden, zu trennen. Der Verfasser hält aber auch auf diesem Wege den Beweis für das Vorhandensein von Rassen noch nicht erbracht. Ford bezeichnet die Heringsschwärme von Plymouth als "complex", ihrer Wirbelzahl, ihrem Wachstum und ihrem Alter nach verschiedenartig. Die Variation in Wachstum und Wirbelzahl wird als individuell angesehen, das Wachstum als von der Ernährung abhängig, die Wirbelzahl nur in gewissen Grenzen erblich, im übrigen aber von äusseren Faktoren abhängig. Dem kann man zustimmen, auch der Schlussfolgerung betreffs der Wirbelzahl, selbst dann,

wenn man im Gegensatz zu Ford sich zur Ansicht vom Vorhandensein von Heringsrassen bekennt. Denn ein Merkmal ist das Produkt von Erbmasse *und* Umwelt. Man kann zu den "äusseren" Faktoren auch noch die "inneren" hinzufügen. Eine andere, noch unentschiedene Frage ist es, ob man heute schon die wirklichen, charakteristischen *Unterschiede* in den Merkmalen erkannt hat.

Ford berichtet dann noch weiter über die Versuche künstlicher Befruchtung und Erbrütung von Heringseiern und die Unmöglichkeit, die so gewonnenen Larven bis zu dem Zeitpunkt weiterzuzüchten, zu dem man Wirbelzählungen vornehmen kann. Die Myomerenzählung stösst auf die bekannten Schwierigkeiten. Auch andere Untersuchungen an Entwicklungsformen sind noch nicht abgeschlossen.

Ein letzter Abschnitt beschäftigt sich mit der besonders praktisch bedeutungsvollen Frage nach den Möglichkeiten für eine Voraussage der Fischereierträge. Auf Grund einer sehr eingehenden Prüfung aller mit dieser Frage in Zusammenhang stehenden Umstände kommt Ford zu der Schlussfolgerung, dass eine regelmässige Beobachtung der Veränderungen in der Zusammensetzung und Grösse der Anlandungen gewisse Rückschlüsse auf Grösse und Beschaffenheit zukünftiger Fänge zulässt, dass aber die Fangergebnisse in erheblichem Masse von Umständen abhängig sind, die nicht vorauszusehen sind, und zur Klärung dieser Fragen hält Ford weitere Untersuchungen für besonders notwendig.

Schmakenbeck.

D. E. Thursby-Pelham. "Report on the English Plaice Investigations during the Years 1926 to 1930". Min. of Agric. and Fish., Fish. Invest. Ser. II, Vol. XII, No. 5, 1932. London, 1932.

This paper deals with the biological-statistical data of plaice collected from market measurements at Lowestoft, and from fishing experiments during the years 1926—30. The investigation falls into four sections. By means of tables and charts the development of the English plaice fishery in the North Sea during the years 1926—1930 is shown. Section I. The total landings have declined, and it appears that from 1929 to 1930 this decline — partially at least — is due to a smaller abundance of plaice, while the abundance during 1926—28 seems to have increased. A direct decision on the question is not possible on account of a change from the common otter-trawl to various forms of the V.-D. trawl. Besides this decline in the total landings the smallest and least valuable sizes have been steadily rising, while the more valuable fish have become increasingly more scarce.

Section II deals with the fluctuations in the strength of the year-classes and with the effect of this and of the varying fishing intensity on the landings at Lowestoft. The rich spawning years 1920—22 dominated the catch during 1926—28, and the effect of the poor spawning years 1923 and 1924 was felt in 1929; by 1930 the majority of the fish landed both by weight and number were below five years old. The effect of the natural fluctuations was increased by the rapidity with which the stock was removed by fishing. There are signs that the stock of mature fish is being reduced to a dangerously low level.

Moreover the investigations of the average size of fish of the same age have shown that there is no clear indication that the intensive fishing of recent years has accelerated growth. They have carried Miss Thursby-Pelham to the conclusion that "it is believed that this method of studying the rate of growth is not a reliable one; in consequence considerable doubts

are entertained as to the truth of the belief that the growth-rate of plaice was checked by the partial cessation of fishing during the war". Yet I think that the statement (on p. 56) that there may be "a connection between the average size of a very abundant year-class and those of a very sparse one" elucidated by the investigation is greatly in favour of the view that the average size of the age-groups found from the fishing experiments is a fairly good expression for the size of the age-groups. Naturally other factors than the density of the stock influence the size of the age-groups, e. g., the natural variations from year to year in the amount of plaice food, of the temperature and of the fishing. The question is a very complex one and not to be discussed in a short review. Here I shall only refer to the fact that the competition for food for a certain age-group is determined neither by the amount of plaice of this age-group alone, nor by the density found at the moment of the investigation only, and further that at a certain spot, there is, during spring and autumn, quite a different stock of plaice owing to the seasonal wanderings.

It is quite certain that Miss T h u r s b y - P e l h a m is right in the view that the average size of an age-group gives no direct indication of the growth of the plaice, but that it is a compound product essentially of growth and fishing intensity. Only with equal fishing conditions a difference in the average size of a certain age-group in two years may indicate the difference in growth. It is to be hoped that the general use of the expression "growth" for difference in average size of a certain age-group and of the next one found by fishing experiments will now disappear.

In Section III the size composition of the stock is shown to be about the same from 1926 to 1930. The cause of the above-named alteration of the size composition of the landings is essentially to be sought for in a displacement of the fishing towards the young plaice grounds.

Section IV gives a survey of the North Sea plaice fishery showing that the fishes are taken as soon as they leave the young plaice grounds, and that a great many undersized plaice are destroyed. The development is to the disadvantage especially of the English fishermen, as the young plaice grounds are situated at some distance from their coasts.

The investigation, moreover, is made more valuable by the many interesting details in the text and in the extensive tables of data.

Aage J. C. Jensen.

H. J. Buchanan-Wollaston. "Inshore Trawl Fisheries of Dorset and Devon. Report on Researches carried out between 1924 and 1929 from Poole, Dorset, and Beer, Devon, with Recommendations bearing on Protective Legislation." Min. of Agric. and Fish., Fish. Invest. Series II, Vol. XIII, No. 1, 1933. London, 1933.

Questions of the regulation of sea fisheries present different aspects in regions physically and economically distinct. Investigations in each case must be planned and carried out in accordance with local needs and conditions. The southern coast of England, for instance, stands in striking contrast with the smooth, shallow and sandy shores of the Continent, from Calais to Skagen. The eastern coast of the North Sea appears as a vast nursery for annual broods of fish which withdraw progressively from the shore as they grow. The "harvest of the sea" in this coastal region is, there, a passing procession, out of which continental and British fishermen endeavour to snatch a profitable booty; but no part of the vagrant fish population of the sea may be considered as the property of any particular town or district of the coast.

Conditions appear to be different in the part of the South Coast between the Isle of Wight and Start Point, explored by Mr. Wollaston. Several places on that coast, especially deep bights with a narrow entrance, seem to enjoy a certain isolation as fish ponds, restricted only by the fact that annual recruits for the stock of inshore fisheries must of necessity come from the outside, and that at a certain age all uncaptured fishes must escape and migrate to distant parts of the high sea. Such conditions may exist not only in nearly land-locked waters like Poole harbour, but also, to a certain extent, in broader inlets like Christchurch Bay, Poole Bay, Tor Bay and even the extensive Lyme Bay.

In those areas partly divided from the open sea, measures for protecting young but already marketable fish might be attempted, for the benefit of local fisheries. Mr. Wollaston collects in a very fully documented memoir "intended as a guide to the local Authorities" some of the results obtained from his activity in that direction, and worked out in conformity with the latest statistical methods, of which he is a well known promoter.

The work is divided into two sections, I. General and Mesh Regulations; II. Regulation of Fisheries.

All biologists engaged in fishery studies ought to read the entire paper and compare the conditions described with those prevailing in their own areas. Some of the principal conclusions arrived at are as follows.

1. Trawling is the most productive method for the fishermen of the region, "where there is the necessary trawling ground near home".
2. The trawl is also the most destructive fishing gear. Regulation of trawling is, therefore, more important than that of other methods.
3. Important series of experiments carried out with the trousertrawl and with covered trawls of different mesh proved that the adoption of a $3^1/_2$ in. mesh would effect a great saving of undersized flatfish.

Mr. Wollaston expresses the opinion, based on experimental data, that an ordinary cod-end even without any special design to hold the meshes open is a very efficient saving gear, if the meshes are proportioned to the size of fish to be saved.

4. The *sole*, however, would offer great difficulties to the imposition of a $3^1/_2$ in. mesh, as this would entail a considerable loss of young but already marketable individuals.
5. A series of comparative fishings made by one experienced fisherman has shown that a 3 in.-mesh trawl "fishes better" than one with smaller meshes; it catches less of the smaller soles and rubbish, but more of the larger ones. In fact, the average total weight and market value of the catch was higher when the larger mesh was used.
6. A 3 in. mesh would effect a satisfactory saving and is likely to be accepted as a compromise by the fishermen of all ports, even by those at present using a mesh of $2^1/_2$ in. in double twine.
7. The closure of certain parts of the coast, as, for instance, Poole harbour, would be beneficial to the local fishery. Concerning all kinds of restrictive measures, the author wisely declares that each district must be dealt with separately, having regard to local conditions, in order "not unduly to affect the source of livelihood of trawl fishermen".
8. From numerous markings of plaice, it appears that the growth-rate at Poole and Beer is very high, the annual increment for groups 0, I and II, being approximately 10 cm.
9. Interesting remarks are made on the bifurcation of the line in the

diagrams representing the recaptures of marked fishes; the lower branch of the bifurcating graph corresponding to "bad recoverers". These remarks should be taken into consideration in all marking experiments, as the variable proportion of bad recoverers, if combined with that of the normal cases, makes the calculation of the average increment liable to inaccuracy.

10. The growth of small plaice from the Dutch grounds, transplanted to Poole harbour, was *much lower* than that of the local fish of similar size.

    This shows that the currently accepted notion of a constant acceleration of growth in fishes transplanted from a crowded region to another with more food and a higher growth-rate may not be applied indiscriminately, and the fact that the fishes transplanted to Poole harbour immediately left the inner water, should be kept in mind in all experiments tending to increase the population of a locality by transplanting young individuals from a region in which very different physical and biological conditions prevail.

11. The author considers that to protect undersized fish, some way must be found *to prevent their capture.* This result may be obtained by the complete or seasonal closure of certain areas.

Nevertheless, a partial saving of fish already captured by the trawl can be obtained by the use of meshes permitting the escape of a certain percentage of undersized individuals. But this method can only be applied to high sea fishing or to inshore fisheries like those of the coast of Devon, where shrimping is unimportant. The limitation of the meshes to dimensions allowing the escape of *Crangon* will never be accepted by the powerful shrimping industry carried on along the whole length of the Continental coast, including the German Bight.

Mr. Wollaston rightly expresses the opinion that the introduction of a size-limit on young fish landed might be an effective method of protection, but that this is "a matter for national regulation and international agreement".

G. Gilson.

A. J. C. Jensen. "Periodic Fluctuations in the Size of Various Stocks of Fish and their Causes". Medd. Komm. f. Havunders. Ser. Fiskeri, Vol. IX, Nr. 5. København, 1933.

Durch die Untersuchungen der letzten Jahre haben wir Schwankungen in der Grösse und Zusammensetzung fast aller Nutzfischbestände kennen gelernt. Der Verfasser behandelt hier im Besonderen periodische Schwankungen, d. h. solche, bei denen sich gleiche Phasen in gleichen Zeitabständen wiederholen. Die Methodik solcher Untersuchungen wird an 4 verschiedenen Beispielen durchgeführt. Das erste betrifft die Anlandungen der dänischen Schollenfischerei aus der östlichen Nordsee 1892—1914. Diese Fischerei war stets so intensiv, dass Schwankungen in der Grösse des (marktfähigen) Bestandes sich in den Erträgen derselben fühlbar machen mussten. — Die Veränderungen in der Stärke der Fischerei etc. werden eliminiert, indem eine Normalkurve des Fanges gezeichnet wird. Die prozentischen Abweichungen der Erträge von dieser Normalen, die "Fanganomalien", zeigen Wellenberge und Täler in ziemlich regelmässiger Folge. Die oberflächliche Betrachtung lässt eine Periode von 2.7 Jahren erkennen. Nun wird eine Schar von Sinuskurven berechnet, deren Periode

zwischen 2.81 und 2.59 Jahren liegt (wobei der in einem Jahre durchlaufene Teil der Schwingung 128 bis 139° beträgt). Aber nicht nur die passendste Periodenlänge muss ausprobiert werden, sondern auch der passendste Wert für die Phase, in der die Schwingung sich im Ausgangsjahr befindet. So finden wir für nicht weniger als 25 Fälle den Korrelationskoeffizienten zwischen der Fanganomalie und den aus den Sinusschwingungen abgeleiteten Werten berechnet. Die schärfste Korrelation ergibt sich für eine Periode von 2.69 Jahren und eine Ausgangsphase von 230°. Die mathematische Prüfung ergibt, dass die Existenz einer solchen Periode in den Anlandungsanomalien wahrscheinlich ist. Freilich braucht es sich nicht gerade um eine Sinuslinie zu handeln. Diese ist vielmehr als bequeme erste Annäherung benutzt. Eine genauere Bestimmung der Kurvenform gestattet das Material nicht. — Nun werden nach Berechnung des Regressionskoeffizienten die durch die festgestellte Periode bedingten Abweichungen von den Fanganomalien abgezogen. Die dann verbleibenden Anomalien zeigen noch eine Periode von 10 Jahren, mit einer Phase von 0 Grad und einer mittl. Abweichung von 19 %. Berechnet man die Korrelation der Fanganomalien mit einer Kombination beider Sinusschwingungen, so erhält man einen sehr grossen Korrelationskoeffizienten. Nach Abzug beider Schwingungen tritt wiederum eine Periode von 4.8—5 Jahren in den verbleibenden Fanganomalien in Erscheinung. Nach Abzug auch dieser bleibt nur noch weniger als die Hälfte der ursprünglichen Anomalien als nicht auf periodische Schwankungen zurückzuführen übrig. — Es folgt sodann eine eingehende Diskussion der Ursachen der periodischen Schwankungen. Die Periode von 2.7 Jahren wird auf die Fluktuation in der Stärke der Jahrgänge zurückgeführt. Diese steht aber für das Hornsriffgebiet in einer gewissen Beziehung zu den Windverhältnissen. Im Winter (Februar) beeinträchtigen Winde aus dem Sektor N—O. diejenigen Strömungen, die Schollenbrut von den Laichplätzen heranführen können. Es zeigt sich, dass die Häufigkeit dieser Winde gleichfalls eine Periode aufweist, die allerdings in dem kritischen Zeitraum mit 3.13 Jahren etwas länger ist als die in den Anlandungen. Der Unterschied wird durch Veränderungen im Wachstum der Schollen erklärt. Dies muss unter dem Einfluss der zunehmenden Befischung durchgehend schneller geworden sein, sodass die Fluktuationen in der Stärke der Jahrgänge sich in den Anlandungen marktfähiger Schollen immer frühzeitiger bemerkbar machten. — Diese Auffassungen werden dadurch gestützt, dass für die Periode 1920—1930 eine deutliche Beziehung zwischen den Windverhältnissen und der Stärke der Jahrgänge einerseits, zwischen dieser und der Höhe der Erträge der Fischerei 3—4 Jahre später andererseits besteht. — Die Periode von ca. 5 Jahren wird in Beziehung zu den Wachstumsschwankungen gebracht, die durch das Auftreten reicher Jahrgänge herbeigeführt werden. Die Verzögerung des Wachstums, die am stärksten beim reichen Jahrgang selbst, minder stark auch bei den nächstfolgenden in Erscheinung tritt, verliert an Bedeutung, wenn die Abkömmlinge des reichen Jahrgangs im Alter von ca. 5 Jahren die Jungfischgründe verlassen. — Die 10 jährige Periode kommt in dem Material nur ca. zweimal vor und ihre Realität ist daher noch zweifelhaft.

Zum zweiten untersucht der Verfasser die Stärke der Schollenjahrgänge im südlichen Kattegat und der Beltsee (nach den Befunden über die Häufigkeit der 0- und 1-Gruppe). Er findet hier eine Periode von 2.4 Jahren und nach deren Eliminierung eine weitere von ca. 3 Jahren. Die Ursache dieser Fluktuationen wird in gleichfalls periodischen Schwankungen der hydrographischen Bedingungen gesucht. Jensen findet eine positive Korrelation der Jahrgangsstärke mit den Oberflächentemperaturen im Januar/Februar und eine

negative mit dem Salzgehalt des Tiefenwassers im Februar/April. Die Temperatur beeinflusst die Schnelligkeit der Entwicklung der Schollenbrut, und damit den Grad der Sterblichkeit. Der Salzgehalt des Bodenwassers ist abhängig von der Stärke des Einstromes in die Ostsee. Ist dieser stark, so muss er viel Schollenbrut aus der Beltsee in die Ostsee entführen, während das von Norden nachströmende Wasser keine wesentlichen Brut-Mengen in das Gebiet einführt. Das widerspricht der Auffassung Johansens, der die Schwankungen in der Strahlenzahl der Analflosse bei den Jahrgängen auf die wechselnde Zufuhr von Larven der Nordseerasse durch die Strömung zurückführen wollte und eine Korrelation mit dem Salzgehalt des Oberflächenwassers feststellte. Der Transport von Larven der Nordrasse dürfte aber nicht im Oberflächenwasser erfolgen, sondern in der Tiefe. Jensen aber findet zwischen Salzgehalt des Oberflächenwassers und der Strahlenzahl nur eine unsichere, zwischen Salzgehalt des Tiefenwassers und Strahlenzahl gar eine ausgesprochene negative Korrelation. Unter diesen Umständen ist Johansens Ansicht kaum mehr zu halten. Eine befriedigende Erklärung der Schwankungen in der Zahl der Flossenstrahlen ist nicht zu finden.

In ähnlicher Weise werden periodische Schwankungen im dänisch-schwedischen Makrelenfang im Skagerrack und Kattegat nachgewiesen und in Verbindung gebracht mit gleichfalls periodischen Schwankungen gewisser hydrographischer Verhältnisse. Für die dänische Heringsfischerei bei Bornholm hat Jensen schon früher eine Periode von 3.7 Jahren nachgewiesen, die Ursache dafür sucht er in Fluktuationen, die in der Menge der in den einzelnen Jahren laichenden Heringe begründet sind. Die Länge der Periode fällt mit dem Durchschnittsalter der geschlechtsreifen Heringe zusammen.

Der Fachgenosse muss die gewaltige Arbeit bewundern, die in der vorliegenden Abhandlung steckt. Die sorgfältige Ausarbeitung und konsequente Anwendung der gewählten Untersuchungsmethode sind gleichfalls hoch anzuerkennen. Diese kann in manchen Fällen, wenn hinreichend sichere Unterlagen gegeben sind, sehr fruchtbar sein. Gross ist ferner die Zahl der Einzeltatsachen, die im Zusammenhang mit den Untersuchungen diskutiert werden.

Ref. darf aber seine grossen Bedenken gegen den von Jensen beschrittenen Weg nicht verhehlen. Derartige Zahlenreihen wie z. B. die Anlandungsstatistik werden von zahlreichen Faktoren beeinflusst, deren Zusammenwirken gar wohl zu periodischen Schwankungen führen kann. Sehr fraglich aber scheint es mir zu sein, ob man diese Schwankungen nach einem mathematischen Verfahren wieder in die realen Komponenten zerlegen kann, aus denen sie resultieren. Jensen weist z. B. darauf hin, dass in der Befischung und im Wachstum der Beltseeschollen in den letzten Jahrzehnten derartige Veränderungen eingetreten sind, dass die Erträge nicht in unmittelbarer Abhängigkeit von den Fluktuationen stehen können. Trotzdem fand Schostakowitsch nach einfacher Glättung der Fangdaten eine Periode von 2.5 Jahren, die also fast die gleiche Länge hat wie Jensens Periode der Jahrgangsstärke. Solche Beobachtungen mahnen zur Vorsicht. Weiter können auch die Erklärungen, die Jensen für die periodischen Schwankungen gibt, nicht befriedigen, geschweige denn überzeugen. In manchen Punkten könnte der Sachkenner wahrscheinlich gewichtige Einwendungen erheben, und im ganzen genommen wird man den Erklärungen keinen höheren Wert zumessen als den von Arbeitshypothesen, deren Richtigkeit durch unmittelbare Untersuchungen zu prüfen ist. Wo eine unmittelbare Beziehung zweier Erscheinungen durch die Korrelations-

berechnung bewiesen werden kann, ist zudem die Berechnung der Periodizität ein Umweg. Das gilt um so mehr, als die Periodizität in der unabhängigen Variablen — den hydrographischen Verhältnissen — mehrfach weniger scharf hervortritt als in der abhängigen, der Fangmenge oder der Stärke der Jahrgänge. — Zu bevorzugen ist daher der Weg direkter Untersuchungen der Anlandungen, die die Ursachen der Schwankungen zweifellos klarer und richtiger erkennen lassen als theoretische Analysen. Die Korrelationsberechnung sollte in erster Linie zur Demonstration von anderweitig erkannten Zusammenhängen, und nur mit grosser Vorsicht zum Aufsuchen unbekannter Zusammenhänge benutzt werden.

Bückmann.

F. T. K. Pentelow, B. A. Southgate and R. Bassindale. "I. Relation between the Size, Age and Time of Migration of Salmon and Sea Trout Smolts in the River Tees.

II. The Proportion of the Sexes and the Food of Smolts of Salmon and Sea Trout in the Tees Estuary."

Min. of Agric. and Fish., Fish. Invest., Ser. I, Vol. III, Nr. 4, 1933. London, 1933.

The material on which these reports was based consisted of smolts of salmon and sea trout which had been killed by industrial pollution in the Tees estuary during their migration to the sea. For determination of age and time of migration 503 salmon and 453 sea trout smolts were examined; for determination of sex, 3,063 salmon and 1,977 sea trout smolts; for determination of stomach contents 3,207 salmon and 2,058 sea trout smolts.

The smolts had spent two or three years in the river before migration, the percentage of two-year old salmon being 95, of sea trout 74. The average length of all the salmon smolts measured was 14.7 cm. in 1930, 14.5 cm. in 1931; that of the sea trout was 17.3 cm. in 1930 and 17.8 cm. in 1931. The average length of the 2-year and 3-year groups is given in Table 4. There appear to be some small discrepancies in this table apparently due to the average lengths of the smolts having been derived from measurements of 4,465 salmon smolts and 3,334 sea trout smolts, whilst the average lengths of the two and three-year old groups were based on the examination of only 503 salmon and 453 sea trout smolts.

A considerable proportion of the fish — 27 % of the salmon smolts in 1930 and 46 % in 1931, 22 % of the sea trout smolts in 1930, and 42 % in 1931 — show on their scales a zone of open ridges outside the last winter band, indicating growth of the scales in freshwater during the year of migration. This phenomenon has apparently not been previously noted in salmon or sea trout smolts from Great Britain, though it characterises the smolts in many Irish rivers. Adequate samples of the smolts were measured at regular intervals from April 24th to June 12th in 1930, a period of 50 days, and from April 21th to June 2nd in 1931, a period of 40 days. During these periods, the proportion of smolts having new growth on their scales greatly increased, from 0 % to 80 % and from 0 % to 90 % in the case of salmon smolts, from 3 % to 78 % and from 21 % to 65 % in the case of sea trout smolts in the two years. Nevertheless, as the authors point out, the average length of the smolts measured remained almost constant during the periods of 50 and 40 days (Table 6), though the salmon smolts of 1931 do show some increase, nor was there any significant difference between the average lengths of those

smolts which had new growth on their scales and those which had not (Table 7).

From this remarkable constancy in *average* length throughout periods of 50 and 40 days, during which the great majority of individuals were presumably increasing fairly rapidly in length, the authors infer that "those smolts which delayed their migration until they had made some extra growth were, at the beginning of the migration period, smaller, on the average, than those migrating without any further growth. Calculations from the scales of the size at the end of the second winter show that on the whole the smallest smolts waited longest and made most growth before they migrated (Table 8). It appears therefore that size is a factor of importance in inducing migration, and those smolts which formed the 2 + group were, at the beginning of the migration period, too small to have a strong impulse to leave the river. As a result of the increased food supply in the spring they made sufficient growth to bring them to the normal size at which smolts migrate".

On p. 10 the authors conclude "In general it is necessary for smolts to attain a physiological condition which is connected with a certain size before they migrate. They also refer to "a definite minimum size".

In considering these observations and conclusions it must be borne in mind that they are based on the *average* measurements of groups of smolts. Some of these averages are obtained by actual measurements of smolts and some are deduced from scale measurements. The actual measurements of smolts show that, throughout the period of migration, from April 24th to June 2nd, the average size remains constant, but scale examination revealed that, in a large proportion of individuals, the scales were gradually adding new growth. The authors assume (p. 3) that this scale growth corresponds and is proportional to growth in length of the fish. This assumption is not now generally accepted as strictly valid, at any rate for the earlier years of life. After surveying the literature bearing on this matter, Graham[1]) says (p. 39): "The truth of the matter is pretty clear. It is evident that length of scale and fish are not in strict linear proportion, nor their increments". The relation of scale growth to growth in length of the fish has recently been investigated by Dunlop[2]) for Sockeye Salmon and by Duff[3]) for Cod.

Dannevig and Høst[4]), after examining the scales of a number of species of fish, including salmon and trout, say (p. 76), "The conclusion can be drawn, however, that in many species at least the scale does not grow in correspondence with the total length of the fish". This latter report gives the results of measurements of scales taken from various parts of the body of a number of species of fish, including salmon and trout, and the authors show that there are significant differences in the calculated lengths of the earlier years according to the position of the fish of the scales measured. Those scales which give the smallest values for the earlier

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[1]) M. Graham. "Studies of Age-Determination in Fish. Part II. A. Survey of the Literature". Min. of Agric. and Fish., Fish. Invest., Series II, Vol. XI, *Oncorhynchus nerka*". Contrib. Canad. Biol., N.S. Vol. II. No. 10, 1924. No. 3, 1928.

[2]) H. A. Dunlop. "The Growth-Rate of the Scales in the Sockeye Salmon,

[3]) G. Lyman Duff. "Factors involved in the production of annual zones in the scales of the cod *(Gadus callarias,* L)" ibid. N. S. Vol. IV. No. 21, 1929.

[4]) Alf Dannevig and Per Høst. "Sources of Error in Computing $l_1 - l_2$ etc. from Scales taken from Different Parts of the Fish." Journal du Conseil, Vol. VI, No. 1, 1931.

years show the greatest marginal growth, i.e., growth in the year of capture. The authors say (p. 76), "the margin of the scale in all specimens plays a considerable part in compensating the less growth in earlier years". The scales of salmon do not appear until the fish is about 3 cm. in length, and for the first year or two they grow relatively faster than does the fish itself. Though the growth of the scale in relation to the growth in length of the fish has not been investigated for the Atlantic salmon and though the investigation of Dannevig and Høst dealt with a different matter, it is highly probable that during the freshwater life of the salmon the relatively more rapid growth of the scales occurs during the early spring months. This rapid growth is represented by the marginal growth in the case of those salmon smolts which show scale growth in the year of migration. If this conclusion, as yet unproven, turns out to be correct, then the assumption that the scale growth of the Tees smolts, during the spring of migration, represents equivalent growth in length of the smolts is not valid. The figures given by the authors (Table 8) of the calculated size of the smolts before this growth begins, on which they base their theory of a "definite minimum size" before migration begins, are not in themselves very conclusive and they will be even less so if the growth during the spring of migration has been exaggerated. The remarkable constancy in the length of the smolts measured (Table 6) refers only to the average length of groups of smolts. There is a wide range in the length of individuals, and in considering whether a definite minimum size is attained before migration, this is of more significance than the close agreement of average lengths. The length frequency curves (Figs. 2 and 3) indicate that there is a considerable overlap in the lengths of those smolts which migrated without scale growth in the year of descent and the calculated lengths of those smolts, at the end of their second and third winters, which remained in the river until growth of the scales recommenced. A further well-established fact which appears to tell against the theory of a definite minimum size before migration is the presence in tidal waters of many parr which have descended from the rivers and which feed and grow in brackish waters long before they reach the true smolt stage. [5])

It has been observed that many of the earliest descending smolts have not yet assumed silver dress[6]).

Though there appears to be a close relation between the rate of growth and the number of years spent in the river before migration, we do not consider, for reasons given above, that the authors have established their conclusion that, of the smolts which will migrate in any particular year, the smaller ones remain in the river and grow until they have reached a definite minimum size.

As regards sex, the females exceeded the males in the ratio of 1.93 for salmon and 2.77 for sea trout. A large proportion of the male salmon smolts had enlarged testes, but the authors do not say whether these fish were ripening or spent. The males with enlarged testes were proportionately more numerous in the larger than in the smaller smolts, and they also tended to migrate at an earlier date than did the immature males. The absence of male sea trout smolts with enlarged testes confirms previous experience.

Of the 3,207 salmon smolts and 2,058 sea trout smolts examined, 14.5 % of the former and 10.5 % of the latter contained undigested food.

[5]) G. H. Nall. "The Life of the Sea Trout", p. 33.

[6]) J. Berry. "Report of an Investigation of the Migration of Smolts in the River Tay during Spring 1931". Fisheries, Scotland, Salmon Fish., 1931, No. VI, p. 13.

The great majority of the feeding fish were found near the upper limit of the belt of polluted water. The most important food organism was *Gammarus duebeni,* which occurred in 67 % of the feeding salmon smolts and 70 % of the feeding sea trout smolts. Other important constituents of the food were larvae of Chironomidae, Ephemeroptera and Trichoptera. From collections of the fauna living in the area in which they were feeding, the authors conclude that the smolts, like the brown trout, feed indiscriminately on any convenient animal organism. In general, this conclusion is true, but anyone acquainted with the feeding habits of these fishes must have met numerous striking exceptions to it.

R. S.

R. Southern. "The Food and Growth of Brown Trout". Salmon and Trout Mag. Nos. 67, 68 and 69. 1932. Manchester, 1932.

The variability in the size of brown trout is one of the great puzzles of freshwater biology. In some waters the average weight of fish caught will be measured in pounds and in others in ounces; in general, large trout are found in alkaline, calcareous waters, while small ones live in acid waters. It has been assumed that this difference in growth is due to the relative abundance of food in these two types of water, but Mr. Southern finds this apparently obvious explanation unsatisfactory. He gives some very curious data on the food and feeding habits of trout in various Irish lakes and rivers to support his contention and then discusses other possible factors — heredity, the effect of parasites, the animal associates of the trout in the two types of water, and the physical and chemical characteristics of the waters. He is able to dismiss heredity as a factor by arguments based on sound evidence, but so little is known about the others that he finds it impossible to come to any conclusions. He is inclined to think that there may be some chemical factor in hard waters favourable to trout growth, that competition with predatory fishes such as perch and pike may weed out the more slowly growing fish or that in acid waters trout may be more heavily parasitised than in others. Although this paper is very largely speculative it is extremely stimulating and is undoubtedly the most important contribution to the study of the brown trout that has appeared in recent years.

F. T. K. Pentelow.

B. Havinga. "Austern- und Muschelkultur". Handb. Seefisch. Nordeuropas (Lübbert u. Ehrenbaum). Bd. VII, H. 5. Stuttgart, 1932.

It is over forty years since Bashford Dean wrote his description of oyster culture in Europe for the U. S. Commission on Fisheries. Since then Dr. Kändler has given us "Die Kultur der Auster" (in Abderhalden's Handbuch, 1930) which is concerned more closely with methods in relation to localities than with other aspects of oyster culture. Dr. Havinga's book therefore meets a need in placing on record the present state of two by no means unimportant fisheries. He deals with oyster and mussel culture in Holland, Germany, Denmark, Great Britain and Norway. A description of oyster culture in France by Le Danois is to be found in another section of this series (viz., Bd. VII, H. 1), and recently also Hinard and Lambert have given a comprehensive account of this subject. Oyster culture in Italy does not fall within the scope of this publication.

As regards the first-mentioned countries, oyster production in all except Holland is now extremely small or even non-existent. In Holland it is only by intensive and painstaking culture that a productive fishery can be

maintained, and it is to this country that the others mainly turn for seed oysters to replenish their beds. For this reason the author has devoted half the space at his disposal to the development and present methods of the oyster industry in Holland. Interesting features are the organisation of the beds in small leases, and a marked decline in the use of limed tiles, such as are still used in France for catching spat, a method which was at its height in Holland when Bashford Dean wrote. Cultching with cockle shells has now largely taken its place. Interesting also is the centralised sanitary control of shellfish, the development of which, and method of working in Holland, the author describes in some detail.

Mussel culture occupies a subordinate place in the work, only a few pages being devoted to it. The whole work is well illustrated and contains a useful list of literature.

H. P. S.

Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given. but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. Allen's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted (Price, 1 Kr.).

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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Table of Contents.

		Page
1.	**Michael Graham.** The North Sea Cod	159
2.	**Kurt Buch** und **Charley Gustafsson.** Der Salz- und Temperaturfehler von Thymolblau	173
3.	**R. Rallier du Baty.** Montagnes et Vallées Sous-Marines du Golfe de Gascogne	181
4.	**Rex J. Robinson** and **Henry E. Wirth.** Free Ammonia, Albuminoid Nitrogen and Organic Nitrogen in the Waters of the Pacific Ocean off the Coasts of Washington and Vancouver Island	187
5.	**C. L. Utterback** and **Wilhelm Jorgensen.** Absorption of Daylight in the North Pacific Ocean	197
6.	**P. L. Kramp.** An Exceptional Occurrence of *Rhizostoma octopus* and *Chrysaora hysoscella* in the Danish Waters in 1933	211
7.	**R. E. Savage** and **W. C. Hodgson.** Lunar Influence on the East Anglian Herring Fishery	223
8.	**John Van Oosten, H. J. Deason** and **Frank W. Jobes.** A Microprojection Machine Designed for the Study of Fish Scales	241
9.	Correspondence:— Letter to the Editor by **Per Ottestad**	249
10.	Reviews	255
11.	Current Bibliography prepared by the Editor with the assistance of Miss **Thursby-Pelham**	289

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